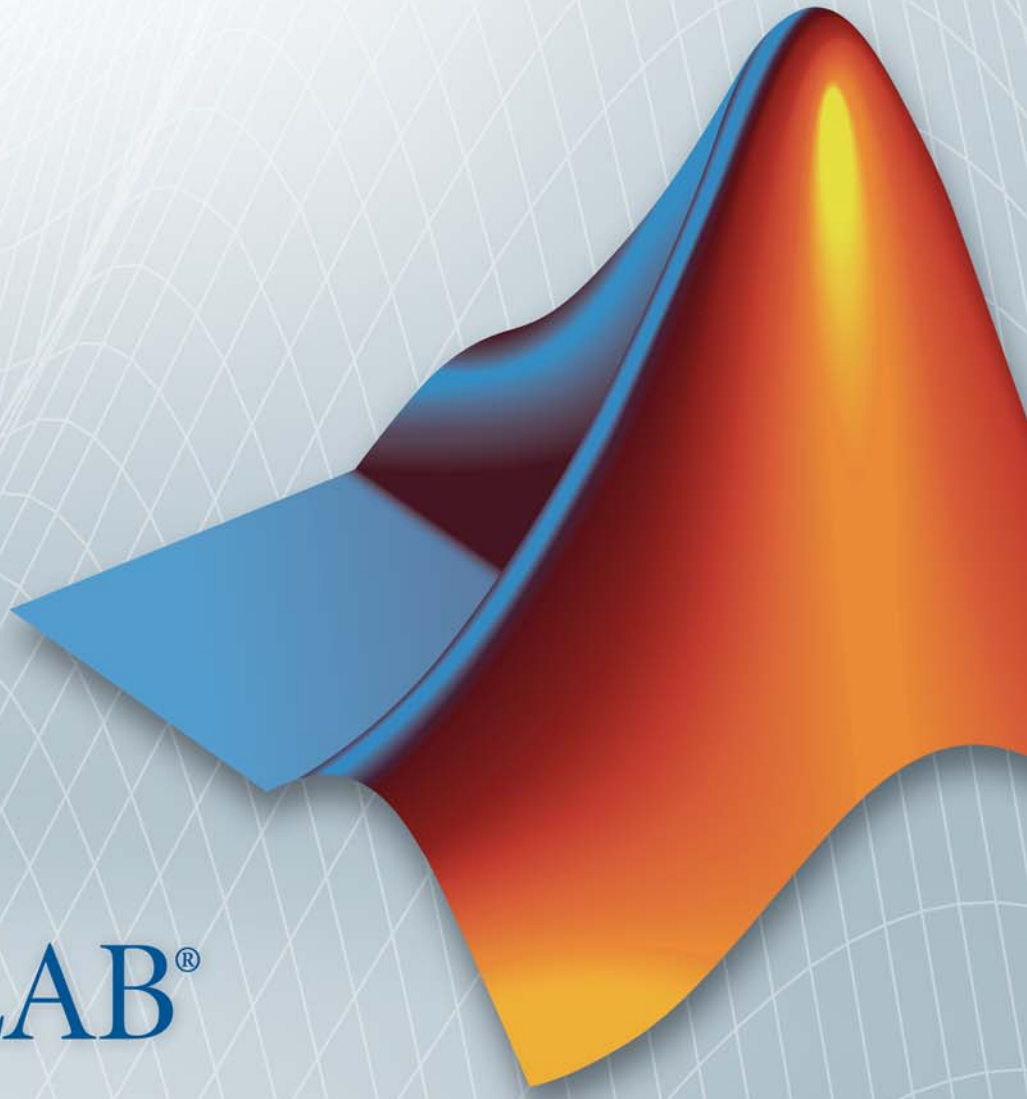
Mapping Toolbox™

Reference

R2012b



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Mapping Toolbox™ Reference

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3 Functions — Alphabetical List

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Function Reference

Geospatial Data Import and Access (p. 1-2)	Readers, writers and associated utilities for geospatial file and data product formats
Web Map Service (p. 1-6)	Finding layers in internal database; retrieving maps from WMS servers
Vector Map Data and Geographic Data Structures (p. 1-8)	Manipulating polygons, geographic data structures and other vector geodata
Georeferenced Images and Data Grids (p. 1-11)	Constructing, georeferencing, analyzing, and manipulating raster geodata
Map Projections and Coordinates (p. 1-17)	Specifying, using, and analyzing map projections and geospatial coordinate transformations
Map Display and Interaction (p. 1-20)	Displaying geographic objects on maps and interacting with them
Geographic Calculations (p. 1-29)	Plane, spherical and ellipsoidal geometry
Utilities (p. 1-35)	Basic tasks, including angle and distance conversions
GUIs (p. 1-38)	GUI tools for selecting data and directly manipulating the content and appearance of maps

Geospatial Data Import and Access

Standard File Formats (p. 1-2)	Reading and writing vector and raster geodata in widely used exchange formats
Gridded Terrain and Bathymetry Products (p. 1-3)	For reading raster data products distributed in special file formats
Vector Map Products (p. 1-4)	For reading vector data products distributed in special file formats
Miscellaneous Data Sets (p. 1-5)	For reading other data products distributed in special file formats
GUIs for Data Import (p. 1-5)	GUIs for browsing data products and selecting areas and objects of interest
File Reading Utilities (p. 1-5)	Low-level access functions for text and other data files

Standard File Formats

arcgridread	Read gridded data set in Arc ASCII Grid Format
geotiffinfo	Information about GeoTIFF file
geotiffread	Read GeoTIFF file
geotiffwrite	Write GeoTIFF file
getworldfilename	Derive worldfile name from image filename
gpxread	Read GPX file
kmlwrite	Write geographic data to KML file
makeattribspec	Attribute specification from geographic data structure
sdtsdemread	Read data from SDTS raster/DEM data set

sdtsinfo	Information about SDTS data set
shapeinfo	Information about shapefile
shaperead	Read vector features and attributes from shapefile
shapewrite	Write geographic data structure to shapefile
worldfileread	Read world file and return referencing object or matrix
worldfilewrite	Write world file from referencing object or matrix

Gridded Terrain and Bathymetry Products

dted	Read U.S. Department of Defense Digital Terrain Elevation Data (DTED)
dteds	DTED filenames for latitude-longitude quadrangle
etopo	Read gridded global relief data (ETOPO products)
globedem	Read Global Land One-km Base Elevation (GLOBE) data
globedems	GLOBE data filenames for latitude-longitude quadrangle
gtopo30	Read 30-arc-second global digital elevation data (GTOPO30)
gtopo30s	GTOPO30 data filenames for latitude-longitude quadrangle
satbath	Read 2-minute terrain/bathymetry from Smith and Sandwell
tbase	Read 5-minute global terrain elevations from TerrainBase

usgs24kdem	Read USGS 7.5-minute (30-m or 10-m) Digital Elevation Models
usgsdem	Read USGS 1-degree (3-arc-second) Digital Elevation Model
usgsdems	USGS 1-degree (3-arc-sec) DEM filenames for latitude-longitude quadrangle

Vector Map Products

dcwdata	Read selected DCW worldwide basemap data
dcwgaz	Search DCW worldwide basemap gazette file
dcwread	Read DCW worldwide basemap file
dcwrhead	Read DCW worldwide basemap file headers
fipsname	Read Federal Information Processing Standard (FIPS) name file used with TIGER thinned boundary files
gshhs	Read Global Self-Consistent Hierarchical High-Resolution Shoreline
tgrline	Read TIGER/Line data
vmap0data	Read selected data from Vector Map Level 0
vmap0read	Read Vector Map Level 0 file
vmap0rhead	Read Vector Map Level 0 file headers

Miscellaneous Data Sets

avhrrgoode	Read AVHRR data product stored in Goode Projection
avhrrlambert	Read AVHRR data product stored in eqaazim projection
egm96geoid	Read 15-minute gridded geoid heights from EGM96
readfk5	Read Fifth Fundamental Catalog of Stars

GUIs for Data Import

demdataui	UI for selecting digital elevation data
vmap0ui	UI for selecting data from Vector Map Level 0

File Reading Utilities

grepfields	Identify matching fields in fixed record length files
readfields	Read fields or records from fixed-format files
readmtx	Read matrix stored in file
spcread	Read columns of data from ASCII text file

Web Map Service

WMS Server and Layer Information (p. 1-6)	For searching local database for relevant layers and servers
WMS Capabilities Information (p. 1-6)	For retrieving capabilities information from WMS server
WMS Map Rendering (p. 1-7)	For rendering WMS map

WMS Server and Layer Information

disp (WMSLayer)	Display properties
refine (WMSLayer)	Refine search
refineLimits (WMSLayer)	Refine search based on geographic limits
servers (WMSLayer)	Return URLs of unique servers
serverTitles (WMSLayer)	Return titles of unique servers
updateLayers (WebMapServer)	Update layer properties
WebMapServer	Web map server object
WMSCapabilities	Web Map Service capabilities object
wmsfind	Search local database for Web map servers and layers
WMSLayer	Web Map Service layer object
wmsupdate	Synchronize WMSLayer object with server

WMS Capabilities Information

disp (WMSCapabilities)	Display properties
getCapabilities (WebMapServer)	Get capabilities document from server
WebMapServer	Web map server object

WMSCapabilities	Web Map Service capabilities object
wmsinfo	Information about WMS server from capabilities document

WMS Map Rendering

boundImageSize (WMSMapRequest)	Bound size of raster map
getMap (WebMapServer)	Get raster map from server
WebMapServer	Web map server object
WMSMapRequest	Web Map Service map request object
wmsread	Retrieve WMS map from server

Vector Map Data and Geographic Data Structures

Geographic Data Representation (p. 1-8)	For updating and obtaining fields from data structures
Data Manipulation (p. 1-9)	For altering, combining, and analyzing polygon and line data
Utilities for NaN-Separated Polygons and Lines (p. 1-10)	For structuring vectors defining multiple line or polygon objects

Geographic Data Representation

extractfield	Field values from structure array
extractm	Coordinate data from line or patch display structure
geopoint	Geographic point vector
updategeostruct	Convert line or patch display structure to geostruct

geopoint Class

append (geopoint)	Append features to geopoint vector
cat (geopoint)	Concatenate geopoint vectors
disp (geopoint)	Display geopoint vector
fieldnames (geopoint)	Dynamic properties of geopoint vector
isempty (geopoint)	True if `geopoint` vector is empty
isfield (geopoint)	Returns true if dynamic property exists
isprop (geopoint)	Returns true if property exists
length (geopoint)	Number of elements in geopoint vector

properties (geopoint)	Properties of a geopoint vector
rmfield (geopoint)	Remove dynamic property from geopoint vector
rmprop (geopoint)	Remove properties from geopoint vector
size (geopoint)	Size of `geopoint` vector
struct (geopoint)	Convert geopoint vector to scalar structure
vertcat (geopoint)	Vertical concatenation for geopoint vectors

Data Manipulation

bufferm	Buffer zones for latitude-longitude polygons
flatearthpoly	Insert points along date line to pole
interpm	Densify latitude-longitude sampling in lines or polygons
intrplat	Interpolate latitude at given longitude
intrplon	Interpolate longitude at given latitude
ispolycw	True if polygon vertices are in clockwise order
nanclip	Clip vector data with NaNs at specified pen-down locations
poly2ccw	Convert polygon contour to counterclockwise vertex ordering
poly2cw	Convert polygon contour to clockwise vertex ordering
poly2fv	Convert polygonal region to patch faces and vertices

polycut	Polygon branch cuts for holes
polymerge	Merge line segments with matching endpoints
reducem	Reduce density of points in vector data

Utilities for NaN-Separated Polygons and Lines

closePolygonParts	Close all rings in multipart polygon
isShapeMultipart	True if polygon or line has multiple parts
polyjoin	Convert line or polygon parts from cell arrays to vector form
polysplit	Convert line or polygon parts from vector form to cell arrays
removeExtraNanSeparators	Clean up `NaN` separators in polygons and lines

Georeferenced Images and Data Grids

Spatial Referencing (p. 1-11)	Computing bounds and converting between geographic and raster coordinates for spatially referenced images and grids
Spatial Referencing Objects (p. 1-12)	Constructing and converting objects to reference rasters to geographic or map coordinates
Terrain Analysis (p. 1-14)	Computing slope, aspect, lines of sight, and terrain visibility
Other Analysis/Access (p. 1-15)	Computing areas and profiles, and selecting subsets of values from data grids
Construction and Modification (p. 1-15)	Constructing, encoding, seeding, reorienting, and converting data grids
Initialization (p. 1-16)	Generating data grids containing uniform values

Spatial Referencing

latlon2pix	Convert latitude-longitude coordinates to pixel coordinates
limitm	Determine latitude and longitude limits of regular data grid
makerefmat	Construct affine spatial-referencing matrix
map2pix	Convert map coordinates to pixel coordinates
mapbbox	Compute bounding box of georeferenced image or data grid

mapoutline	Compute outline of georeferenced image or data grid
meshgrat	Construct map graticule for surface object display
pix2map	Convert pixel coordinates to map coordinates
pixcenters	Compute pixel centers for georeferenced image or data grid
refmat2vec	Convert referencing matrix to referencing vector
refmatToWorldFileMatrix	Convert referencing matrix to world file matrix
refvec2mat	Convert referencing vector to referencing matrix
setltln	Convert data grid rows and columns to latitude-longitude
setpostn	Convert latitude-longitude to data grid rows and columns
worldFileMatrixToRefmat	Convert world file matrix to referencing matrix

Spatial Referencing Objects

georasterref	Construct `spatialref.GeoRasterReference` object
maprasterref	Construct `spatialref.MapRasterReference` object
refmatToGeoRasterReference	Referencing matrix to GeoRasterReference object

refmatToMapRasterReference	Referencing matrix to `MapRasterReference` object
refvecToGeoRasterReference	Referencing vector to `GeoRasterReference` object

GeoRasterReference Class

contains (spatialref.GeoRasterReference)	True if raster contains latitude-longitude points
geographicToIntrinsic (spatialref.GeoRasterReference)	Convert from geographic to intrinsic coordinates
geographicToSub (spatialref.GeoRasterReference)	Geographic coordinates to row and column subscripts
intrinsicToGeographic (spatialref.GeoRasterReference)	Convert from intrinsic to geographic coordinates
intrinsicXToLongitude (spatialref.GeoRasterReference)	Convert from intrinsic *x* to longitude
intrinsicYToLatitude (spatialref.GeoRasterReference)	Convert from intrinsic *y* to latitude
latitudeToIntrinsicY (spatialref.GeoRasterReference)	Convert from latitude to intrinsic *y*
longitudeToIntrinsicX (spatialref.GeoRasterReference)	Convert from longitude to intrinsic *x*
sizesMatch (spatialref.GeoRasterReference)	True if object and raster or image are size compatible
spatialref.GeoRasterReference	Reference raster to geographic coordinates
worldFileMatrix (spatialref.GeoRasterReference)	World file parameters for transformation

MapRasterReference Class

contains (spatialref.MapRasterReference)	True if raster contains points in world coordinate system
firstCornerX (spatialref.MapRasterReference)	World *x* coordinate of the (1,1) corner of the raster
firstCornerY (spatialref.MapRasterReference)	World *y* coordinate of the (1,1) corner of the raster
intrinsicToWorld (spatialref.MapRasterReference)	Convert from intrinsic to world coordinates
sizesMatch (spatialref.MapRasterReference)	True if object and raster or image are size compatible
spatialref.MapRasterReference	Reference raster to map coordinates
worldFileMatrix (spatialref.MapRasterReference)	World file parameters for transformation
worldToIntrinsic (spatialref.MapRasterReference)	Convert from world to intrinsic coordinates
worldToSub (spatialref.MapRasterReference)	World coordinates to row and column subscripts

Terrain Analysis

gradientm	Calculate gradient, slope and aspect of data grid
los2	Line-of-sight visibility between two points in terrain
viewshed	Areas visible from point on terrain elevation grid

Other Analysis/Access

areamat	Surface area covered by nonzero values in binary data grid
filterm	Filter latitudes and longitudes based on underlying data grid
findm	Latitudes and longitudes of nonzero data grid elements
ltln2val	Extract data grid values for specified locations
mapprofile	Interpolate between waypoints on regular data grid

Construction and Modification

changem	Substitute values in data array
encodem	Fill in regular data grid from seed values and locations
geoloc2grid	Convert geolocated data array to regular data grid
imbedm	Encode data points into regular data grid
neworig	Orient regular data grid to oblique aspect
resizem	Resize regular data grid
sizem	Row and column dimensions needed for regular data grid
vec2mtx	Convert latitude-longitude vectors to regular data grid

Initialization

nanm	Construct regular data grid of NaNs
onem	Construct regular data grid of 1s
spzerom	Construct sparse regular data grid of 0s
zerom	Construct regular data grid of 0s

Map Projections and Coordinates

Available Map Projections (p. 1-17)	Lists of map projections and characteristics
Map Projection Transformations (p. 1-18)	Forward and inverse map projection functions
Map Trimming (p. 1-18)	For trimming lines, polygons, and data grids to latitude-longitude quadrangles
Angles, Scales, and Distortions (p. 1-18)	Computing directions, angles, and distortions on projected maps
Visualizing Map Distortions (p. 1-19)	Generating displays of distortion statistics and Tissot ellipses
UTM System (p. 1-19)	Selecting zones and ellipsoids for the Universal Transverse Mercator system
Coordinate Rotation on the Sphere (p. 1-19)	Reorienting map data by solid-body rotations on the sphere
Trimming and Clipping (p. 1-19)	Removing and replacing data that extends outside a map frame

For specific map projections, see “Supported Map Projections”.

Available Map Projections

maplist	Available Mapping Toolbox™ map projections
maps	List available map projections and verify names
projlist	Map projections supported by `projfwd` and `projinv`

Map Projection Transformations

mfwdtran	Project geographic features to map coordinates
minvtran	Unproject features from map to geographic coordinates
projfwd	Forward map projection using `PROJ.4` map projection library
projinv	Inverse map projection using `PROJ.4` map projection library

Map Trimming

maptriml	Trim lines to latitude-longitude quadrangle
maptrimp	Trim polygons to latitude-longitude quadrangle
maptrims	Trim regular data grid to latitude-longitude quadrangle

Angles, Scales, and Distortions

distortcalc	Distortion parameters for map projections
vfwdtran	Direction angle in map plane from azimuth on ellipsoid
vinvtran	Azimuth on ellipsoid from direction angle in map plane

Visualizing Map Distortions

mdistort	Display contours of constant map distortion
tissot	Project Tissot indicatrices on map axes

UTM System

utmgeoid	Select ellipsoids for given UTM zone
utmzone	Select UTM zone given latitude and longitude

Coordinate Rotation on the Sphere

newpole	Origin vector to place specific point at pole
org2pol	Location of north pole in rotated map
putpole	Origin vector to place north pole at specified point

Trimming and Clipping

clipdata	Clip data at `+/-pi` in longitude, `+/-pi` in latitude
trimcart	Trim graphic objects to map frame
trimdata	Trim map data exceeding projection limits
undoclip	Remove object clips introduced by `clipdata`
undotrim	Remove object trims introduced by `trimdata`

Map Display and Interaction

Map Creation and High-Level Display (p. 1-21)	Top-level functions that create map axes, project map data onto them, and control symbolization
Vector Symbolization (p. 1-21)	Functions that draw symbols for points, lines, and polygons (coordinate lists and geostructs)
Lines and Contours (p. 1-21)	Lower level line plotting and higher level contour plotting functions
Patch Data (p. 1-22)	Lower-level functions for plotting polygons as patches on map axes
Data Grids (p. 1-22)	For mapping regular and geolocated data grids in 2-D and 3-D
Light Objects and Lighted Surfaces (p. 1-23)	For mapping regular and geolocated data grids using lighting and shading
Thematic Maps (p. 1-23)	For making scatter, quiver, comet, and stem maps
Map Annotation (p. 1-23)	For adding north arrows, graphic scales, text and other annotations to maps
Colormaps for Map Displays (p. 1-24)	For constructing colormaps appropriate for map displays
Interactive Map Positions (p. 1-24)	For graphic interaction with data in map axes
Interactive Track and Circle Definition (p. 1-25)	For constructing great and small circles, rhumb lines and other geographic tracks
GUIs (p. 1-25)	GUIs for specific functions and general GUIs for interactive mapping
Map Object and Projection Properties (p. 1-26)	For querying, setting, and modifying map axes objects and properties

Map Appearance (p. 1-27)	For controlling the view and map scale
Display Clearing (p. 1-27)	For showing, hiding, and removing objects from map axes

Map Creation and High-Level Display

axesm	Define map axes and set map properties
displaym	Display geographic data from display structure
geoshow	Display map latitude and longitude data
grid2image	Display regular data grid as image
mapshow	Display map data without projection
mapview	Interactive map viewer
usamap	Construct map axes for United States of America
worldmap	Construct map axes for given region of world

Vector Symbolization

makesymbolspec	Construct vector layer symbolization specification

Lines and Contours

contour3m	Project 3-D contour plot of map data
contourfm	Project filled 2-D contour plot of map data

contourm	Project 2-D contour plot of map data
linem	Project line object on map axes
plot3m	Project 3-D lines and points on map axes
plotm	Project 2-D lines and points on map axes

Patch Data

fill3m	Project filled 3-D patch objects on map axes
fillm	Project filled 2-D patch objects on map axes
patchesm	Project patches on map axes as individual objects
patchm	Project patch objects on map axes

Data Grids

meshm	Project regular data grid on map axes
pcolorm	Project regular data grid on map axes in z = 0 plane
surfacem	Project and add geolocated data grid to current map axes
surfm	Project geolocated data grid on map axes

Light Objects and Lighted Surfaces

lightm	Project light objects on map axes
meshlsrm	3-D lighted shaded relief of regular data grid
shaderel	Construct `cdata` and colormap for shaded relief
surflm	3-D shaded surface with lighting on map axes
surflsrm	3-D lighted shaded relief of geolocated data grid

Thematic Maps

comet3m	Project 3-D comet plot on map axes
cometm	Project 2-D comet plot on map axes
quiverm	Project 2-D quiver plot on map axes
scatterm	Project point markers with variable color and area
stem3m	Project stem plot map on map axes
symbolm	Project point markers with variable size

Map Annotation

clabelm	Add contour labels to map contour display
clegendm	Add legend labels to map contour display
contourcbar	Color bar for filled contour map display

framem	Toggle and control display of map frame
gridm	Toggle and control display of graticule lines
lcolorbar	Colorbar with text labels
mlabel	Toggle and control display of meridian labels
mlabelzero22pi	Convert meridian labels to 0-360 degree range
northarrow	Add graphic element pointing to geographic North Pole
plabel	Toggle and control display of parallel labels
rotatetext	Rotate text to projected graticule
scaleruler	Add or modify graphic scale on map axes
textm	Project text annotation on map axes

Colormaps for Map Displays

contourcmap	Contour colormap and colorbar for current axes
polcmap	Colormaps appropriate to political regions

Interactive Map Positions

gcpmap	Current mouse point from map axes
gtextm	Place text on map using mouse
inputm	Latitudes and longitudes of mouse-click locations

Interactive Track and Circle Definition

scircleg	Small circle defined via mouse input
sectorg	Sector of small circle defined via mouse input
trackg	Great circle or rhumb line defined via mouse input

GUIs

clrmenu	Add colormap menu to figure window
colorm	Create index map colormaps
colorui	Interactively define RGB color
getseeds	Interactively assign seeds for data grid encoding
lightmui	Control position of lights on globe or 3-D map
maptool	Add menu-activated tools to map figure
maptrim	Interactively trim and convert map data from vector to raster format
mlayers	GUI to control plotting of display structure elements
mobjects	Manipulate object sets displayed on map axes
originui	Interactively modify map origin
panzoom	Pan and zoom on map axes
parallelui	Interactively modify map parallels
qrydata	GUI to interactively perform data queries

rootlayr	Construct cell array of workspace variables for `mlayers` tool
seedm	GUI to fill data grids with seeded values
surfdist	Interactive distance, azimuth, and reckoning calculations
uimaptbx	Handle buttondown callbacks for mapped objects
utmzoneui	Choose or identify UTM zone by clicking map

Map Object and Projection Properties

cart2grn	Transform projected coordinates to Greenwich system
defaultm	Initialize or reset map projection structure
gcm	Current map projection structure
geotiff2mstruct	Convert GeoTIFF information to map projection structure
getm	Map object properties
handlem	Handles of displayed map objects
ismap	True for axes with map projection
ismapped	True, if object is projected on map axes
makemapped	Convert ordinary graphics object to mapped object
namem	Determine names of valid graphics objects
project	Project displayed map graphics object

restack	Restack objects within map axes
rotatem	Transform vector map data to new origin and orientation
setm	Set properties of map axes and graphics objects
tagm	Set property of map graphics object
zdatam	Adjust *z*-plane of displayed map objects

Map Appearance

axesscale	Resize axes for equivalent scale
camposm	Set camera position using geographic coordinates
camtargm	Set camera target using geographic coordinates
camupm	Set camera up vector using geographic coordinates
daspectm	Control vertical exaggeration in map display
paperscale	Set figure properties for printing at specified map scale
previewmap	View map at printed size
tightmap	Remove white space around map

Display Clearing

clma	Clear current map axes
clmo	Clear specified graphics objects from map axes

hidem	Hide specified graphic objects on map axes
showaxes	Toggle display of map coordinate axes
showm	Specify graphic objects to display on map axes

Geographic Calculations

Geometry of Sphere and Ellipsoid (p. 1-29)	Distances, deviations, areas, and curves on the sphere or ellipsoid
3-D Coordinates (p. 1-30)	For converting between different 3-D coordinate systems
Reference Ellipsoids and Spheroids (p. 1-31)	For converting ellipsoid parameters and auxiliary latitudes
Geometric Object Overlay (p. 1-32)	For determining if, how, and where points, lines, circles, and areas intersect
Geographic Statistics (p. 1-32)	For computing geographic means, standard deviations, and histograms
Navigation (p. 1-33)	For determining positions, headings, drift, and navigational fixes and way points
Spherical Distance Conversions (p. 1-34)	For converting distances along the surface of the Earth, approximated as a sphere

Geometry of Sphere and Ellipsoid

antipode	Point on opposite side of globe
areaint	Surface area of polygon on sphere or ellipsoid
areaquad	Surface area of latitude-longitude quadrangle
azimuth	Azimuth between points on sphere or ellipsoid
departure	Departure of longitudes at specified latitudes
distance	Distance between points on sphere or ellipsoid

ellipse1	Geographic ellipse from center, semimajor axes, eccentricity, and azimuth
gc2sc	Center and radius of great circle
meridianarc	Ellipsoidal distance along meridian
meridianfwd	Reckon position along meridian
reckon	Point at specified azimuth, range on sphere or ellipsoid
scircle1	Small circles from center, range, and azimuth
scircle2	Small circles from center and perimeter
track1	Geographic tracks from starting point, azimuth, and range
track2	Geographic tracks from starting and ending points

3-D Coordinates

ecef2geodetic	Convert geocentric (ECEF) to geodetic coordinates
ecef2lv	Convert geocentric (ECEF) to local vertical coordinates
elevation	Local vertical elevation angle, range, and azimuth
geodetic2ecef	Convert geodetic to geocentric (ECEF) coordinates
lv2ecef	Convert local vertical to geocentric (ECEF) coordinates

Reference Ellipsoids and Spheroids

almanac	Parameters for Earth, planets, Sun, and Moon
axes2ecc	Eccentricity of ellipse from axes lengths
convertlat	Convert between geodetic and auxiliary latitudes
earthRadius	Mean radius of planet Earth
ecc2flat	Flattening of ellipse from eccentricity
ecc2n	Third flattening of ellipse from eccentricity
flat2ecc	Eccentricity of ellipse from flattening
geocentric2geodeticLat	Convert geocentric to geodetic latitude
geodetic2geocentricLat	Convert geodetic to geocentric latitude
majaxis	Semimajor axis of ellipse
minaxis	Semiminor axis of ellipse
n2ecc	Eccentricity of ellipse from third flattening
oblateSpheroid	Oblate ellipsoid of revolution
rcurve	Ellipsoidal radii of curvature
referenceEllipsoid	Reference ellipsoid
referenceSphere	Reference sphere
rsphere	Radii of auxiliary spheres
wgs84Ellipsoid	Reference ellipsoid for World Geodetic System 1984

Geometric Object Overlay

circcirc	Intersections of circles in Cartesian plane
gcxgc	Intersection points for pairs of great circles
gcxsc	Intersection points for great and small circle pairs
ingeoquad	True for points inside or on lat-lon quadrangle
intersectgeoquad	Intersection of two latitude-longitude quadrangles
linecirc	Intersections of circles and lines in Cartesian plane
outlinegeoquad	Polygon outlining geographic quadrangle
polybool	Set operations on polygonal regions
polyxpoly	Intersection points for lines or polygon edges
rhxrh	Intersection points for pairs of rhumb lines
scxsc	Intersection points for pairs of small circles

Geographic Statistics

combntns	All possible combinations of set of values
eqa2grn	Convert from equal area to Greenwich coordinates
grn2eqa	Convert from Greenwich to equal area coordinates

hista	Histogram for geographic points with equal-area bins
meanm	Mean location of geographic coordinates
stdist	Standard distance for geographic points
stdm	Standard deviation for geographic points

Navigation

crossfix	Cross-fix positions from bearings and ranges
dreckon	Dead reckoning positions for track
driftcorr	Heading to correct for wind or current drift
driftvel	Wind or current from heading, course, and speeds
gcwaypts	Equally spaced waypoints along great circle
legs	Courses and distances between navigational waypoints
navfix	Mercator-based navigational fix
timezone	Time zone based on longitude
track	Track segments to connect navigational waypoints

Spherical Distance Conversions

deg2km	Convert distance from degrees to kilometers
deg2nm	Convert distance from degrees to nautical miles
deg2sm	Convert distance from degrees to statute miles
km2deg	Convert distance from kilometers to degrees
km2rad	Convert distance from kilometers to radians
nm2deg	Convert distance from nautical miles to degrees
nm2rad	Convert distance from nautical miles to radians
rad2km	Convert distance from radians to kilometers
rad2nm	Convert distance from radians to nautical miles
rad2sm	Convert distance from radians to statute miles
sm2deg	Convert distance from statute miles to degrees
sm2rad	Convert distance from statute miles to radians

Utilities

Angle Unit Conversions (p. 1-35)	For converting angles between different units and encodings
Conversion Factors for Angles and Lengths (p. 1-36)	Function to compute factor for converting between units of angle or length
Data Precision (p. 1-36)	For managing data precision
Length Unit Conversions (p. 1-36)	For converting between different units of length
Image Conversion (p. 1-36)	Function for changing indexed images to uint8 true-color images
String Formatters (p. 1-37)	For formatting angles and lengths or distances as text suitable for annotations
Longitude or Azimuth Wrapping (p. 1-37)	For forcing angles to lie within specified intervals
Validation (p. 1-37)	

Angle Unit Conversions

degrees2dm	Convert degrees to degrees-minutes
degrees2dms	Convert degrees to degrees-minutes-seconds
degtorad	Convert angles from degrees to radians
dm2degrees	Convert degrees-minutes to degrees
dms2degrees	Convert degrees-minutes-seconds to degrees
fromDegrees	Convert angles from degrees
fromRadians	Convert angles from radians

radtodeg	Convert angles from radians to degrees
str2angle	Convert strings to angles in degrees
toDegrees	Convert angles to degrees
toRadians	Convert angles to radians

Conversion Factors for Angles and Lengths

unitsratio	Unit conversion factors

Data Precision

epsm	Accuracy in angle units for certain map computations
roundn	Round to multiple of 10

Length Unit Conversions

km2nm	Convert kilometers to nautical miles
km2sm	Convert kilometers to statute miles
nm2km	Convert nautical miles to kilometers
nm2sm	Convert nautical to statute miles
sm2km	Convert statute miles to kilometers
sm2nm	Convert statute to nautical miles

Image Conversion

ind2rgb8	Convert indexed image to uint8 RGB image

String Formatters

angl2str	Format angle strings
dist2str	Format distance strings

Longitude or Azimuth Wrapping

unwrapMultipart	Unwrap vector of angles with NaN-delimited parts
wrapTo180	Wrap angle in degrees to [-180 180]
wrapTo2Pi	Wrap angle in radians to [0 2*pi]
wrapTo360	Wrap angle in degrees to [0 360]
wrapToPi	Wrap angle in radians to [−pi pi]

Validation

validateLengthUnit	Validate and standardize length unit string

GUIs

Map Definition Tools (p. 1-38)	Selecting vector and raster data, defining map axes, and projection parameters
Mapping Tools (p. 1-39)	Displaying maps, manipulating layers, and querying map objects
Display Manipulation Tools (p. 1-39)	Controlling zoom levels, colormaps, and lighting
Object Property Tools (p. 1-39)	Showing, hiding, tagging, and clearing objects, and customizing colormaps
Track Tools (p. 1-40)	Plotting small and great circles, rhumb lines, and other navigational tracks
Map Data Construction Tools (p. 1-40)	Setting limits, trimming maps, and seeding grid values

Map Definition Tools

axesmui	Define map axes and modify map projection and display properties
demdataui	UI for selecting digital elevation data
originui	Interactively modify map origin
parallelui	Interactively modify map parallels
utmzoneui	Choose or identify UTM zone by clicking map
vmap0ui	UI for selecting data from Vector Map Level 0

Mapping Tools

maptool	Add menu-activated tools to map figure
maptrim	Interactively trim and convert map data from vector to raster format
mapview	Interactive map viewer
mlayers	GUI to control plotting of display structure elements
mobjects	Manipulate object sets displayed on map axes
qrydata	GUI to interactively perform data queries

Display Manipulation Tools

clrmenu	Add colormap menu to figure window
hidem-ui	Hide specified mapped objects
lightmui	Control position of lights on globe or 3-D map
panzoom	Pan and zoom on map axes

Object Property Tools

clmo	Clear specified graphics objects from map axes
colorui	Interactively define RGB color
handlem	Handles of displayed map objects
handlem-ui	GUI for handles of specified mapped objects
hidem	Hide specified graphic objects on map axes

property editors	GUIs to edit properties of mapped objects
showm	Specify graphic objects to display on map axes
tagm	Set property of map graphics object
zdatam	Adjust *z*-plane of displayed map objects

Track Tools

scircleg	Small circle defined via mouse input
scirclui	GUI to display small circles on map axes
sectorg	Sector of small circle defined via mouse input
surfdist	Interactive distance, azimuth, and reckoning calculations
trackg	Great circle or rhumb line defined via mouse input
trackui	GUI to display great circles and rhumb lines on map axes

Map Data Construction Tools

colorm	Create index map colormaps
seedm	GUI to fill data grids with seeded values

2

Class Reference

- "Reference Spheroids" on page 2-2
- "Spatial Referencing" on page 2-3
- "Vector Geographic Data" on page 2-5
- "Web Map Service" on page 2-6

Reference Spheroids

In this section...

"oblateSpheroid" on page 2-2
"referenceSphere" on page 2-2
"referenceEllipsoid " on page 2-2

oblateSpheroid

oblateSpheroid	Oblate ellipsoid of revolution

referenceSphere

referenceSphere	Reference sphere

referenceEllipsoid

referenceEllipsoid	Reference ellipsoid

Spatial Referencing

In this section...
“spatialref.GeoRasterReference” on page 2-3
“spatialref.MapRasterReference” on page 2-4

spatialref.GeoRasterReference

contains	True if raster contains latitude-longitude points
geographicToIntrinsic	Convert from geographic to intrinsic coordinates
geographicToSub	Geographic coordinates to row and column subscripts
intrinsicToGeographic	Convert from intrinsic to geographic coordinates
intrinsicXToLongitude	Convert from intrinsic *x* to longitude
intrinsicYToLatitude	Convert from intrinsic *y* to latitude
latitudeToIntrinsicY	Convert from latitude to intrinsic *y*
longitudeToIntrinsicX	Convert from longitude to intrinsic *x*
sizesMatch	True if object and raster or image are size compatible
spatialref.GeoRasterReference	Reference raster to geographic coordinates
worldFileMatrix	World file parameters for transformation

spatialref.MapRasterReference

contains	True if raster contains points in world coordinate system
firstCornerX	World *x* coordinate of the (1,1) corner of the raster
firstCornerY	World *y* coordinate of the (1,1) corner of the raster
intrinsicToWorld	Convert from intrinsic to world coordinates
sizesMatch	True if object and raster or image are size compatible
spatialref.MapRasterReference	Reference raster to map coordinates
worldFileMatrix	World file parameters for transformation
worldToIntrinsic	Convert from world to intrinsic coordinates
worldToSub	World coordinates to row and column subscripts

Vector Geographic Data

geopoint

append	Append features to geopoint vector
cat	Concatenate geopoint vectors
disp	Display geopoint vector
fieldnames	Dynamic properties of geopoint vector
isempty	True if `geopoint` vector is empty
isfield	Returns true if dynamic property exists
isprop	Returns true if property exists
length	Number of elements in geopoint vector
properties	Properties of a geopoint vector
rmfield	Remove dynamic property from geopoint vector
rmprop	Remove properties from geopoint vector
size	Size of `geopoint` vector
struct	Convert geopoint vector to scalar structure
vertcat	Vertical concatenation for geopoint vectors

Web Map Service

In this section...
"WebMapServer" on page 2-6
"WMSCapabilities" on page 2-6
"WMSLayer" on page 2-6
"WMSMapRequest" on page 2-7

WebMapServer

getCapabilities	Get capabilities document from server
getMap	Get raster map from server
updateLayers	Update layer properties
WebMapServer	Web map server object

WMSCapabilities

disp	Display properties
WMSCapabilities	Web Map Service capabilities object

WMSLayer

disp	Display properties
refine	Refine search
refineLimits	Refine search based on geographic limits
servers	Return URLs of unique servers
serverTitles	Return titles of unique servers
WMSLayer	Web Map Service layer object

WMSMapRequest

boundImageSize	Bound size of raster map
WMSMapRequest	Web Map Service map request object

3

Functions — Alphabetical List

aer2ecef

Purpose

Local spherical AER to geocentric ECEF

Syntax

```
[X,Y,Z] =
aer2ecef(az,elev,slantRange,lat0,lon0,h0,spheroid)
[ ___ ] = aer2ecef( ___ ,angleUnit)
```

Description

`[X,Y,Z] = aer2ecef(az,elev,slantRange,lat0,lon0,h0,spheroid)` returns Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian coordinates corresponding to coordinates `az`, `elev`, `slantRange` in a local spherical system having the same origin. Any of the first six numerical input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = aer2ecef( ___ ,angleUnit)` adds `angleUnit` which specifies the units of inputs `az`, `elev`, `lat0`, and `lon0`.

Input Arguments

az - Azimuth angles

scalar value | vector | matrix | N-D array

Azimuth angles in the local spherical system, specified as a scalar, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

elev - Elevation angles

scalar value | vector | matrix | N-D array

Elevation angles in the local spherical system, specified as a scalar, vector, matrix, or N-D array. Elevations are with respect to a plane perpendicular to the spheroid surface normal. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

slantRange - Distances from local origin

scalar value | vector | matrix | N-D array

Distances from origin in the local spherical system, returned as a scalar, vector, matrix, or N-D array. The straight-line, 3-D Cartesian distance is used. Units are determined by the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h0 - Ellipsoidal height of local origin

scalar value | vector | matrix | N-D array

Ellipsoidal height of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `h0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

X - ECEF x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

Y - ECEF y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

Z - ECEF z-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

See Also

`aer2geodetic` | `ecef2aer` | `enu2ecef` | `ned2ecef`

aer2enu

Purpose

Local spherical AER to local Cartesian ENU

Syntax

```
[xEast,yNorth,zUp] = aer2enu(az,elev,slantRange)
[ ___ ] = aer2enu( ___ ,angleUnit)
```

Description

`[xEast,yNorth,zUp] = aer2enu(az,elev,slantRange)` returns coordinates in a local east-north-up (ENU) Cartesian system corresponding to coordinates `az`, `elev`, `slantRange` in a local spherical system having the same origin. Any of the three numerical input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = aer2enu( ___ ,angleUnit)` adds `angleUnit` which specifies the units of inputs `az` and `elev`..

Input Arguments

az - Azimuth angles

scalar value | vector | matrix | N-D array

Azimuth angles in the local spherical system, specified as a scalar, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

elev - Elevation angles

scalar value | vector | matrix | N-D array

Elevation angles in the local spherical system, specified as a scalar, vector, matrix, or N-D array. Elevations are with respect to a plane perpendicular to the spheroid surface normal. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

slantRange - Distances from local origin

scalar value | vector | matrix | N-D array

Distances from origin in the local spherical system, returned as a scalar, vector, matrix, or N-D array. The straight-line, 3-D Cartesian distance is used. Units are determined by the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

xEast - Local ENU x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the local ENU system, returned as a scalar value, vector, matrix, or N-D array.

yNorth - Local ENU y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the local ENU system, returned as a scalar value, vector, matrix, or N-D array.

zUp - Local ENU z-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the local ENU system, returned as a scalar value, vector, matrix, or N-D array.

See Also

`aer2ned` | `enu2aer`

aer2geodetic

Purpose

Local spherical AER to geodetic

Syntax

```
[lat,lon,h] = aer2geodetic(az,elev,slantRange,lat0,lon0,h0,
   spheroid)
[ ___ ] = aer2geodetic( ___ ,angleUnits)
```

Description

`[lat,lon,h] = aer2geodetic(az,elev,slantRange,lat0,lon0,h0,spheroid))` returns geodetic coordinates corresponding to coordinates `az`, `elev`, `slantRange` in a local spherical system. Any of the first six numeric input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = aer2geodetic( ___ ,angleUnits)` adds `angleUnit` which specifies the units of inputs `az`, `elev`, `lat0`, `lon0`, and outputs `lat`, `lon`.

Input Arguments

az - Azimuth angles

scalar value | vector | matrix | N-D array

Azimuth angles in the local spherical system, specified as a scalar, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

elev - Elevation angles

scalar value | vector | matrix | N-D array

Elevation angles in the local spherical system, specified as a scalar, vector, matrix, or N-D array. Elevations are with respect to a plane perpendicular to the spheroid surface normal. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

slantRange - Distances from local origin

scalar value | vector | matrix | N-D array

Distances from origin in the local spherical system, returned as a scalar, vector, matrix, or N-D array. The straight-line, 3-D Cartesian distance is used. Units are determined by the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h0 - Ellipsoidal height of local origin

scalar value | vector | matrix | N-D array

Ellipsoidal height of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `h0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

lat - Geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the closed interval [-90 90].

lon - Longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the input argument

`angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the interval [-180 180].

h - Ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object

Examples

Zermatt to the Matterhorn

Compute the latitude, longitude and orthometric height of the summit of the Matterhorn (Monte Cervino) from its azimuth, elevation and (slant) range relative to Zermatt, Switzerland. All distances and lengths are in meters.

Origin (reference point): Zermatt.

```
fmt = get(0,'Format');
format short g

lat0 = dm2degrees([46  1]) % convert degree-minutes to degrees
lon0 = dm2degrees([ 7 45])
hOrthometric0 = 1620;
hGeoid = 53;
h0 = hOrthometric0 + hGeoid
```

```
lat0 =

       46.017


lon0 =

         7.75
```

```
h0 =

        1673
```

Azimuth, elevation, and slant range to Matterhorn summit.

```
az = 237.8;
elev = 18.755;
slantRange = 8871.7;
```

Latitude, longitude, and ellipsoidal height of summit.

```
[lat, lon, hEllipsoidal] = aer2geodetic( ...
    az, elev, slantRange, lat0, lon0, h0, wgs84Ellipsoid)

lat =

       45.976


lon =

       7.6583


hEllipsoidal =

         4531
```

Orthometric height of summit.

```
hGeoid = 53;
hOrthometric = hEllipsoidal - hGeoid
format(fmt)

hOrthometric =

         4478
```

See Also

aer2ecef | enu2geodetic | geodetic2aer | ned2geodetic

aer2ned

Purpose

Local spherical AER to local Cartesian NED

Syntax

```
[xNorth,yEast,zDown] = aer2ned(az,elev,slantRange)
[ ___ ] = aer2ned( ___ ,angleUnit)
```

Description

`[xNorth,yEast,zDown] = aer2ned(az,elev,slantRange)` returns coordinates in a local north—east—down (NED) Cartesian system corresponding to coordinates `az`, `elev`, `slantRange` in a local spherical system having the same origin. Any of the three numerical input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = aer2ned( ___ ,angleUnit)` adds `angleUnit` which specifies the units of inputs `az` and `elev`..

Input Arguments

az - Azimuth angles

scalar value | vector | matrix | N-D array

Azimuth angles in the local spherical system, specified as a scalar, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

elev - Elevation angles

scalar value | vector | matrix | N-D array

Elevation angles in the local spherical system, specified as a scalar, vector, matrix, or N-D array. Elevations are with respect to a plane perpendicular to the spheroid surface normal. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

slantRange - Distances from local origin

scalar value | vector | matrix | N-D array

Distances from origin in the local spherical system, returned as a scalar, vector, matrix, or N-D array. The straight-line, 3-D Cartesian distance is used. Units are determined by the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

xNorth - Local NED x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the local NED system, returned as a scalar value, vector, matrix, or N-D array.

yEast - Local NED y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the local NED system, returned as a scalar value, vector, matrix, or N-D array.

zDown - Local NED z-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the local NED system, returned as a scalar value, vector, matrix, or N-D array.

See Also

`aer2enu` | `ned2aer`

almanac

Purpose

Parameters for Earth, planets, Sun, and Moon

Syntax

```
almanac
almanac(body)
data = almanac(body,parameter)
data = almanac(body,parameter,units)
data = almanac(parameter,units,referencebody)
```

Description

almanac is not recommended. Use `earthRadius`, `referenceEllipsoid`, `referenceSphere`, or `wgs84Ellipsoid` instead.

`almanac` displays the names of the celestial objects available in the almanac.

`almanac(body)` lists the options, or parameters, available for each celestial body. Valid *`body`* strings are

```
'earth'       'pluto'
'jupiter'     'saturn'
'mars'        'sun'
'mercury'     'uranus'
'moon'        'venus'
'neptune'
```

`data = almanac(body,parameter)` returns the value of the requested parameter for the celestial body specified by *`body`*.

Valid *`parameter`* strings are `'radius'` for the planetary radius, `'ellipsoid'` or `'geoid'` for the two-element ellipsoid vector, `'surfarea'` for the surface area, and `'volume'` for the planetary volume.

For the Earth, *`parameter`* can also be any valid predefined ellipsoid string. In this case, the two-element ellipsoid vector for that ellipsoid model is returned. Valid ellipsoid definition strings for the Earth are

`'everest'`	1830 Everest ellipsoid
`'bessel'`	1841 Bessel ellipsoid

`'airy'`	1830 Airy ellipsoid
`'clarke66'`	1866 Clarke ellipsoid
`'clarke80'`	1880 Clarke ellipsoid
`'international'`	1924 International ellipsoid
`'krasovsky'`	1940 Krasovsky ellipsoid
`'wgs60'`	1960 World Geodetic System ellipsoid
`'iau65'`	1965 International Astronomical Union ellipsoid
`'wgs66'`	1966 World Geodetic System ellipsoid
`'iau68'`	1968 International Astronomical Union ellipsoid
`'wgs72'`	1972 World Geodetic System ellipsoid
`'grs80'`	1980 Geodetic Reference System ellipsoid
`'wgs84'`	1984 World Geodetic System ellipsoid

For the Earth, the *`parameter`* strings `'ellipsoid'` and `'geoid'` are equivalent to`'grs80'`.

`data = almanac(`*`body`*`,`*`parameter`*`,`*`units`*`)` specifies the units to be used for the output measurement, where *`units`* is any valid distance units string. Note that these are linear units, but the result for surface area is in square units, and for volume is in cubic units. The default units are `'kilometers'`.

`data = almanac(`*`parameter`*`,`*`units`*`,`*`referencebody`*`)` specifies the source of the information. This sets the assumptions about the shape of the celestial body used in the calculation of volumes and surface areas. A *`referencebody`* string of `'actual'` returns a tabulated value rather than one dependent upon a ellipsoid model assumption. Other possible *`referencebody`* strings are `'sphere'` for a spherical assumption and `'ellipsoid'` for the default ellipsoid model. The default reference body is `'sphere'`.

For the Earth, any of the preceding predefined ellipsoid definition strings can also be entered as a reference body.

For Mercury, Pluto, Venus, the Sun, and the Moon, the eccentricity of the ellipsoid model is zero, that is, the `'ellipsoid'` reference body is actually a sphere.

Tips

Take care when using angular arc length units for distance measurements. All planets have a radius of 1 radian, for example, and an area unit of *square degrees* indicates unit squares, 1 degree of arc length on a side, not 1-degree-by-1-degree quadrangles.

See Also

`distance` | `earthRadius` | `referenceEllipsoid` | `referenceSphere` | `wgs84Ellipsoid`

Purpose

Format angle strings

Syntax

```
str = angl2str(angle)
str = angl2str(angle,signcode)
str = angl2str(angle,signcode,units)
str = angl2str(angle,signcode,units,n)
```

Description

`str = angl2str(angle)` converts a numerical vector of angles in degrees to a string matrix.

`str = angl2str(angle,signcode)` uses the string *`signcode`* to specify the method for indicating that a given angle is positive or negative. *`signcode`* may be one of the following:

`'ew'`	east/west notation; trailing 'e' (positive longitudes) or 'w' (negative longitudes)
`'ns'`	north/south notation; trailing 'n' (positive latitudes) or 's' (negative latitudes)
`'pm'`	plus/minus notation; leading '+' (positive angles) or '-' (negative angles)
`'none'`	blank/minus notation; leading '-' for negative angles or sign omitted for positive angles (the default value)

`str = angl2str(angle,signcode,units)` uses the string *`units`* to indicate both the units in which `angle` is provided *and* to control the output format. *`units`* can be `'degrees'` (the default value), `'radians'`, `'degrees2dm'`, or `'degrees2dms'`. *`units`* may be abbreviated and is case-insensitive. The interpretations of *`units`* are as follows:

Units	Units of Angle	Output Format
`'degrees'`	degrees	decimal degrees
`'degrees2dm'`	degrees	degrees + decimal minutes

Units	Units of Angle	Output Format
'degrees2dms'	degrees	degrees + minutes + decimal seconds
'radians'	radians	decimal radians

`str = angl2str(angle,signcode,units,n)` uses the integer `n` to control the number of significant digits provided in the output. `n` is the power of 10 representing the last place of significance in the number of degrees, minutes, seconds, or radians -- for *`units`* of `'degrees'`, `'degrees2dm'`, `'degrees2dms'`, and `'radians'`, respectively. For example, if `n = -2` (the default), `angl2str` rounds to the nearest hundredth. If `n = -0`, `angl2str` rounds to the nearest integer. And if `n = 1`, `angl2str` rounds to the tens place, although positive values of `n` are of little practical use. In all cases, the interpretation of the parameter `n` is consistent between `angl2str` and `roundn`.

Tips

The purpose of this function is to make angular-valued variables into strings suitable for map display. In general, the interpretation of the parameter `n` by `angl2str` is consistent with that of `roundn`.

Examples

Create a string matrix to represent a series of values in DMS units, using the north-south format:

```
a = -3:1.5:3;
str = angl2str(a,'ns','degrees2dms',-3)

str =
 3^{\circ} 00' 00.000" S
 1^{\circ} 30' 00.000" S
 0^{\circ} 00' 00.000"
 1^{\circ} 30' 00.000" N
 3^{\circ} 00' 00.000" N
```

These LaTeX strings are displayed (using either `text` or `textm`) as

```
3” 00' 00.000" S
1” 30' 00.000" S
0” 00' 00.000"
1” 30' 00.000" N
3” 00' 00.000" N
```

See Also

str2angle | dist2str

angledim

Purpose

Convert angles units

Note The `angledim` function has been replaced by four, more specific, functions: `fromRadians`, `fromDegrees`, `toRadians`, and `toDegrees`. However, `angledim` will be maintained for backward compatibility. The functions `degtorad`, `radtodeg`, and `unitsratio` provide additional alternatives.

Syntax

```
angleOut = angledim(angleIn,from,to)
```

Description

`angleOut = angledim(angleIn,from,to)` returns the value of the input angle `angleIn`, which is in units specified by the valid angle units string *`from`*, in the desired units given by the valid angle units string *`to`*. Angle units strings are `'degrees'` for "decimal" degrees or `'radians'` for radians

Examples

Convert from degrees to radians:

```
angledim(23.45134,'degrees','radians')

ans =
    0.4093
```

See Also

`degrees2dms` | `degtorad` | `fromDegrees` | `fromRadians` | `toDegrees` | `toRadians` | `radtodeg` | `unitsratio`

Purpose

Point on opposite side of globe

Syntax

```
[newlat,newlon] = antipode(lat,lon)
[newlat,newlon] = antipode(lat,lon,angleunits)
```

Description

`[newlat,newlon] = antipode(lat,lon)` returns the geographic coordinates of the points exactly opposite on the globe from the input points given by `lat` and `lon`. All angles are in degrees.

`[newlat,newlon] = antipode(lat,lon,angleunits)` specifies the input and output units with the string *`angleunits`*. The string *`angleunits`* can be either `'degrees'` or `'radians'`. It can be abbreviated and is case-insensitive.

Examples

Example 1

Given a point (43ºN, 15ºE), find its antipode:

```
[newlat,newlong] = antipode(43,15)
newlat =
         -43
newlong =
         -165
```

or (43ºS, 165ºW).

Example 2

Perhaps the most obvious antipodal points are the North and South Poles. The function `antipode` demonstrates this:

```
[newlat,newlong] = antipode(90,0,'degrees')
newlat =
         -90
newlong =
         180
```

Note that in this case longitudes are irrelevant because all meridians converge at the poles.

Example 3

Find the antipode of the location of the MathWorks corporate headquarters in Natick, Massachusetts. Map the headquarters location and its antipode in an orthographic projection. Begin by specifying latitude and longitude as degree-minutes-seconds and then convert to decimal degrees.

```
mwlat = dms2degrees([ 42 18 2.5])
mwlon = dms2degrees([-71 21 7.9])

mwlat =
   42.3007
mwlon =
  -71.3522

[amwlat amwlon] = antipode(mwlat,mwlon)

amwlat =
  -42.3007
amwlon =
  108.6478
```

Prove that these points are antipodes:

```
dist = distance(mwlat,mwlon,amwlat,amwlon)

dist =
  180.0000
```

The `distance` function shows them to be 180 degrees apart.

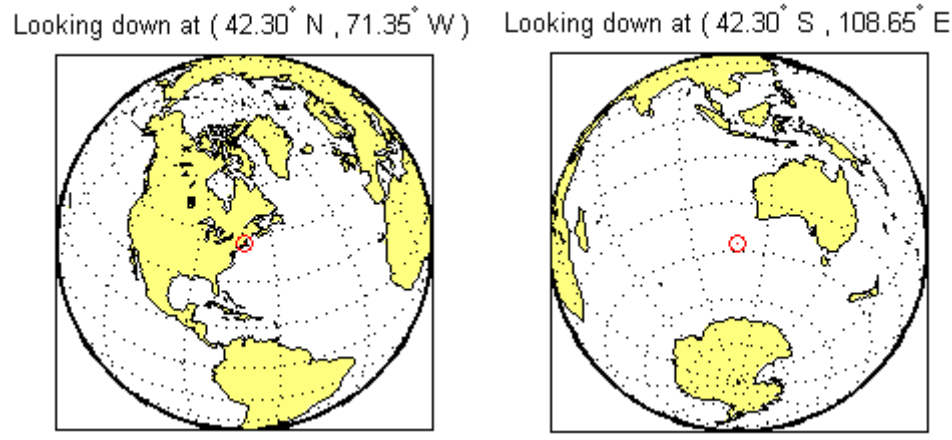
Generate a map centered on the original point:

```
subplot(1,2,1)
axesm ('MapProjection','ortho','origin',[mwlat mwlon],...
       'frame','on','grid','on')
load coast
geoshow(lat,long,'displaytype','polygon')
```

```
geoshow(mwlat,mwlon,'Marker','o','Color','red')
s = ['Looking down at (' angl2str(mwlat,'ns') ...
    ',' angl2str(mwlon,'ew') ')'];
title(s)
```

Add a second map centered on the computed antipodal point:

```
subplot(1,2,2)
axesm ('MapProjection','ortho','origin',[amwlat amwlon],...
       'frame','on','grid','on')
geoshow(lat,long,'displaytype','polygon')
geoshow(amwlat,amwlon,'Marker','o','Color','red')
t = ['Looking down at (' angl2str(amwlat,'ns') ...
    ',' angl2str(amwlon,'ew') ')'];
title(t)
```



arcgridread

Purpose

Read gridded data set in Arc ASCII Grid Format

Syntax

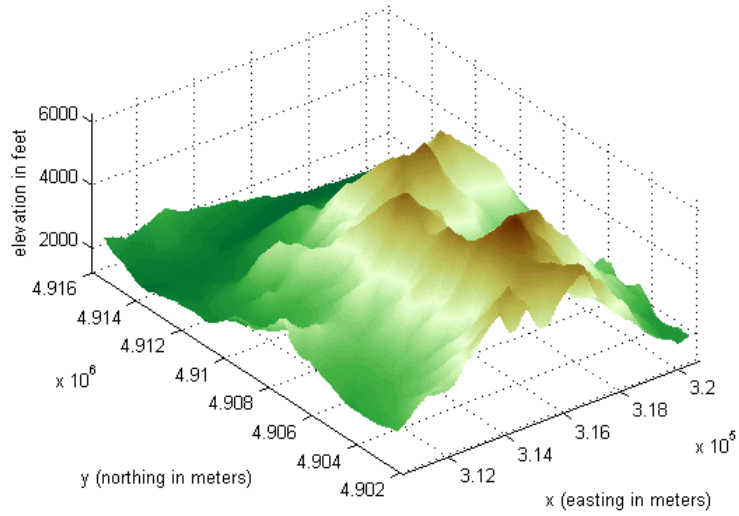
```
[Z,R] = arcgridread(filename)
```

Description

`[Z,R] = arcgridread(filename)` reads a grid from a file in Arc ASCII Grid format. `Z` is a 2-D array containing the data values. `R` is a referencing matrix (see `makrefmat`). `NaN` is assigned to elements of `V` corresponding to null data values in the grid file.

Examples

```
[Z,R] = arcgridread('MtWashington-ft.grd');
mapshow(Z,R,'DisplayType','surface');
xlabel('x (easting in meters)'); ylabel('y (northing in meters)')
demcmap(Z)

% View the terrain in 3-D
axis normal; view(3); axis equal; grid on
zlabel('elevation in feet')
```



See Also

makerefmat | mapshow | sdtsdemread

Purpose

Surface area of polygon on sphere or ellipsoid

Syntax

```
area = areaint(lat,lon)
area = areaint(lat,lon,ellipsoid)
area = areaint(lat,lon,units)
area = areaint(lat,lon,ellipsoid,units)
```

Description

`area = areaint(lat,lon)` calculates the spherical surface area of the polygon specified by the input vectors `lat` and `lon`. The calculation uses a line integral approach. The output, `area`, is the fraction of surface area covered by the polygon on a unit sphere. To supply multiple polygons, separate the polygons by NaNs in the input vectors. Accuracy of the integration method is inversely proportional to the distance between lat/lon points.

`area = areaint(lat,lon,ellipsoid)` calculates the surface area of the polygon on the ellipsoid or sphere defined by the input `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The output, `area`, is in squares units corresponding to the units of `ellipsoid`.

`area = areaint(lat,lon,units)` uses the units defined by the input string `units`. If omitted, default units of degrees are assumed.

`area = areaint(lat,lon,ellipsoid,units)` uses both the inputs `ellipsoid` and `units` in the calculation.

Examples

Consider the area enclosed by a 30º lune from pole to pole and bounded by the prime meridian and 30ºE. You can use the function `areaquad` to get an exact solution:

```
area = areaquad(90,0,-90,30)
area =
    0.0833
```

This is 1/12 the spherical area. The more points used to define this polygon, the more integration steps `areaint` takes, improving the estimate. This first attempt takes a point every 30º of latitude:

```
lats = [-90:30:90,60:-30:-60]';
lons = [zeros(1,7), 30*ones(1,5)]';
area = areaint(lats,lons)
area =
    0.0792
```

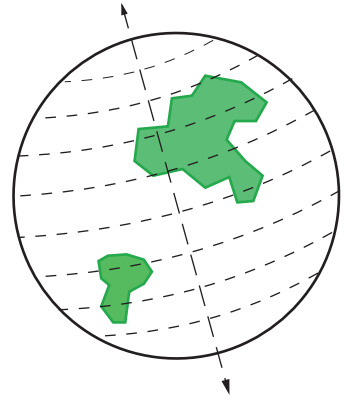
Now, calculate a better estimate, with one point every 1º of latitude:

```
lats = [-90:1:90,89:-1:-89]';
lons = [zeros(1,181), 30*ones(1,179)]';
area = areaint(lats,lons)
area =
    0.0833
```

Algorithms

This function enables the measurement of areas enclosed by arbitrary polygons. This is a numerical estimate, using a line integral based on Green's Theorem. As such, it is limited by the accuracy and resolution of the input data.

Areas are computed for arbitrary polygons on the ellipsoid or sphere



An area is returned for each NaN-separated polygon

Given sufficient data, the `areaint` function is the best method for determining the areas of complex polygons, such as continents, cloud cover, and other natural or derived features. The calculations in this function employ a spherical Earth assumption. For nonspherical ellipsoids, the latitude data is converted to the auxiliary authalic sphere.

See Also

`almanac` | `areamat` | `areaquad`

Purpose

Surface area covered by nonzero values in binary data grid

Syntax

```
A = areamat(BW,R)
A = areamat(BW,refvec,ellipsoid)
[A, cellarea] = areamat(...)
```

Description

`A = areamat(BW,R)` returns the surface area covered by the elements of the binary regular data grid `BW`, which contain the value 1 (`true`). `BW` can be the result of a logical expression such as `BW = (topo > 0)`. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(BW)` and its `RasterInterpretation` must be `'cells'`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to or from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Nearest-neighbor interpolation is used by default. NaN is returned for points outside the grid limits or for which `lat` or `lon` contain NaN. All angles are in units of degrees.

The output `A` expresses surface area as a fraction of the surface area of the unit sphere (4*pi), so the result ranges from 0 to 1.

`A = areamat(BW,refvec,ellipsoid)` calculates the surface area on the ellipsoid or sphere defined by the input `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The

units of the output, A, are the square of the length units in which the semimajor axis is provided. For example, if ellipsoid is replaced with wgs84Ellipsoid('kilometers'), then A is in square kilometers.

[A, cellarea] = areamat(...) returns a vector, cellarea, describing the area covered by the data cells in BW. Because all the cells in a given row are exactly the same size, only one value is needed per row. Therefore cellarea has size M-by-1, where M = size(BW,1) is the number of rows in BW.

Tips

Given a regular data grid that is a logical 0-1 matrix, the areamat function returns the area corresponding to the true, or 1, elements. The input data grid can be a logical statement, such as (topo>0), which is 1 everywhere that topo is greater than 0 meters, and 0 everywhere else. This is an illustration of that matrix:

This calculation is based on the areaquad function and is therefore limited only by the granularity of the cellular data.

Examples

```
load topo
area = areamat((topo>127),topolegend)

area =
    0.2411
```

Approximately 24% of the Earth has an altitude greater than 127 meters. The surface area of this portion of the Earth in square kilometers if a spherical ellipsoid is:

```
earth = referenceSphere('earth', 'km');
area = areamat((topo>127),topolegend,earth)

area =
   1.2299e+08
```

To illustrate the `cellarea` output, consider a smaller map:

```
BW = ones(9,18);
refvec = [.05 90 0] % each cell 20x20 degrees
[area,cellarea] = areamat(BW,refvec)

area =
    1.0000
cellarea =
    0.0017
    0.0048
    0.0074
    0.0091
    0.0096
    0.0091
    0.0074
    0.0048
    0.0017
```

Each entry of `cellarea` represents the portion of the unit sphere's total area a cell in that row of `BW` would contribute. Since the column extends from pole to pole in this case, it is symmetric.

See Also

`areaint` | `areaquad`

areaquad

Purpose

Surface area of latitude-longitude quadrangle

Syntax

```
area = areaquad(lat1,lon1,lat2,lon2)
area = areaquad(lat1,lon1,lat2,lon2,ellipsoid)
area = areaquad(lat1,lon1,lat2,lon2,ellipsoid,units)
```

Description

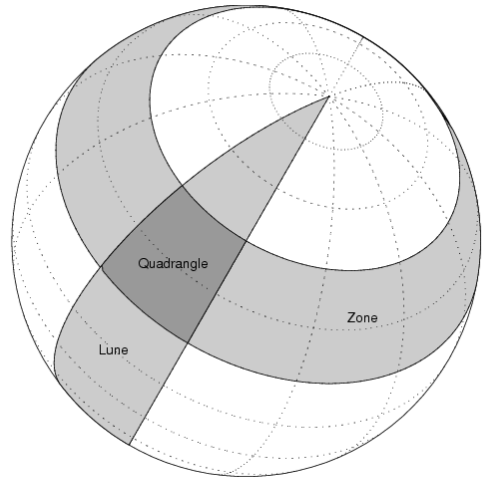
`area = areaquad(lat1,lon1,lat2,lon2)` returns the surface area bounded by the parallels `lat1` and `lat2` and the meridians `lon1` and `lon2`. The output `area` is a fraction of the unit sphere's area of 4π, so the result ranges from 0 to 1.

`area = areaquad(lat1,lon1,lat2,lon2,ellipsoid)` allows the specification of the ellipsoid model with `ellipsoid`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. When `ellipsoid` is input, the resulting `area` is given in terms of the (squared) units of the ellipsoid. For example, if the ellipsoid `referenceEllipsoid('grs80','kilometers')` is used, the resulting area is in km^2.

`area = areaquad(lat1,lon1,lat2,lon2,ellipsoid,units)` specifies the units of the inputs. The default is `'degrees'`.

Definitions

A latitude-longitude quadrangle is a region bounded by two meridians and two parallels. In spherical geometry, it is the intersection of a *lune* (a section bounded by two meridians) and a *zone* (a section bounded by two parallels).



Examples

Find the fraction of the Earth's surface that lies between 30°N and 45°N, and also between 25°W and 60°E:

```
area = areaquad(30,-25,45,60)

area =
    0.0245
```

Assuming a spherical ellipsoid, find the surface area of the Earth in square kilometers.

```
earthellipsoid = referenceSphere('earth','km');
area = areaquad(-90,-180,90,180,earthellipsoid)

area =
   5.1006e+08
```

For comparison,

```
earthellipsoid.SurfaceArea
```

```
ans =
   5.1006e+08
```

Algorithms

The `areaquad` calculation is exact, being based on simple spherical geometry. For nonspherical ellipsoids, the data is converted to the auxiliary authalic sphere.

See Also

`almanac` | `areaint` | `areamat`

Purpose

Read AVHRR data product stored in Goode Projection

Syntax

```
[latgrat,longrat,z] = avhrrgoode(region,filename)
[...] = avhrrgoode(region,filename,scalefactor)
[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim)
[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,
   gsize)
[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize,...
nrows,ncols)
[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize,...
nrows,ncols,resolution)
[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize,...
nrows,ncols,resolution,precision)
```

Description

`[latgrat,longrat,z] = avhrrgoode(region,filename)` reads data from an Advanced Very High Resolution Radiometer (AVHRR) data set with a nominal resolution of 1 km that is stored in the Goode projection. Data in this format includes a nondimensional vegetation index (NDVI) and Global Land Cover Characteristics (GLCC) data sets. `region` is a string that specifies the geographic coverage of the file. Valid region strings are:

- `'g'` or `'global'`
- `'af'` or `'africa'`
- `'ap'` or `'australia/pacific'`
- `'ea'` or `'eurasia'`
- `'na'` or `'north america'`
- `'sa'` or `'south america'`

`filename` is a string specifying the name of the data file. Output `Z` is a geolocated data grid with coordinates `latgrat` and `longrat` in units of degrees. `Z`, `latgrat`, and `longrat` are of class double. Projected coordinates that lie within the interrupted areas of the projection are set to NaN. A scale factor of 100 is applied to the original data set, so that `Z` contains every 100^{th} point in both X and Y directions.

`[...] = avhrrgoode(region,filename,scalefactor)` uses the integer `scalefactor` to downsample the data. A scale factor of 1 returns every point. A scale factor of 10 returns every 10^{th} point. The default value is 100.

`[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim)` returns data for the specified region. The returned data can extend somewhat beyond the requested area. Limits are two-element vectors in units of degrees, with `latlim` in the range `[-90 90]` and `lonlim` in the range `[-180 180]`. `latlim` and `lonlim` must be ascending. If `latlim` and `lonlim` are empty, the entire area covered by the data file is returned. If the quadrangle defined by `latlim` and `lonlim` (when projected to form a polygon in the appropriate Goode projection) fails to intersect the bounding box of the data in the projected coordinates, then `Z`, `latgrat`, and `longrat` are returned as empty.

`[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize)` controls the size of the graticule matrices. `gsize` is a two-element vector containing the number of rows and columns desired. By default, `latgrat`, and `longrat` have the same size as `Z`.

`[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize,...nrows,ncols)` overrides the dimensions for the standard file format for the selected region. This syntax is useful for data stored on CD-ROM, which may have been truncated to fit. Some global data sets were distributed with 16347 rows and 40031 columns of data on CD-ROMs. The default size for global data sets is 17347 rows and 40031 columns of data.

`[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize,...nrows,ncols,`*`resolution`*`)`reads a data set with the spatial resolution specified in meters. Specify `resolution` as either `1000` or `8000` (meters). If empty, the full resolution of 1000 meters is assumed. Data is also available at 8-km spatial resolution. Nondimensional vegetation index data at 8-km spatial resolution has 2168 rows and 5004 columns.

`[...] = avhrrgoode(region,filename,scalefactor,latlim,lonlim,gsize,...nrows,ncols,`*`resolution`*`,`*`precision`*`)` reads a data set expecting the integer `precision` specified. If empty, `'uint8'` is assumed. `'uint16'` is appropriate for some files. Check the metadata (`.txt` or `README`) file in the GLCC `ftp` folder for specification of the file format and contents. In either case, `Z` is converted to class double.

Background

The United States maintains a family of satellite-based sensors to measure climate change under the Earth Observing System (EOS) program. The precursors to the EOS data are the data sets produced by NOAA and NASA under the Pathfinder program. These are data derived from the Advanced High Resolution Radiometer sensor flown on the NOAA Polar Orbiter satellites, NOAA-7, -9, and -11, and have spatial resolutions of about 1 km. The data from the AVHRR sensor is processed into separate land, sea, and atmospheric indices. Land area data is processed to a nondimensional vegetation index (NDVI) or land cover classification and stored in binary files in the Plate Carrée, Goode, and Lambert projections. Sea data is processed to surface temperatures and stored in HDF formats. `avhrrgoode` reads land data saved in the Goode projection with global and continental coverage at 1 km. It can also read 8 km data with global coverage.

Tips

This function reads the binary files as is. You should not use byte-swapping software on these files.

The AVHRR project and data sets are described in and provided by various U.S. Government Web sites. See the entry for Global Land Cover Characteristics (GLCC) in the tech note referred to below.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: `http://www.mathworks.com/help/map/finding-geospatial-data.html`.

Limitations

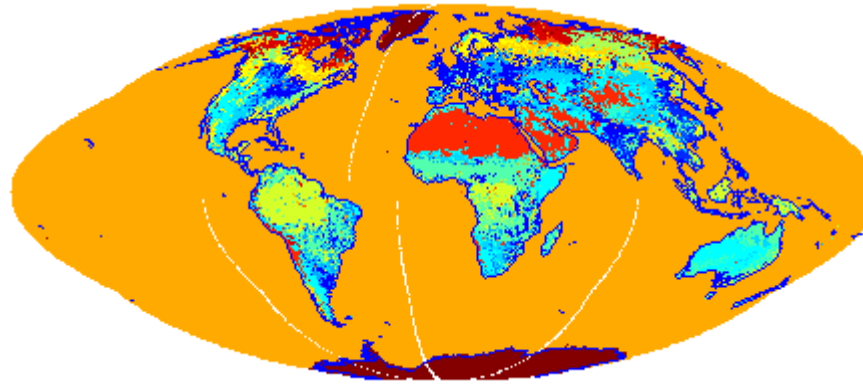
Most files store the data in scaled integers. Though this function returns the data as double, the scaling from integer to float is not performed. Check the data's README file for the appropriate scaling parameters.

Examples

Example 1 — Downsampled Classified Global GLCC Coverage

Read and display every 50th point from the Global Land Cover Characteristics (GLCC) file covering the entire globe with the USGS classification scheme, named `gusgs2_0g.img`. (To run the example, you must first download the file.)

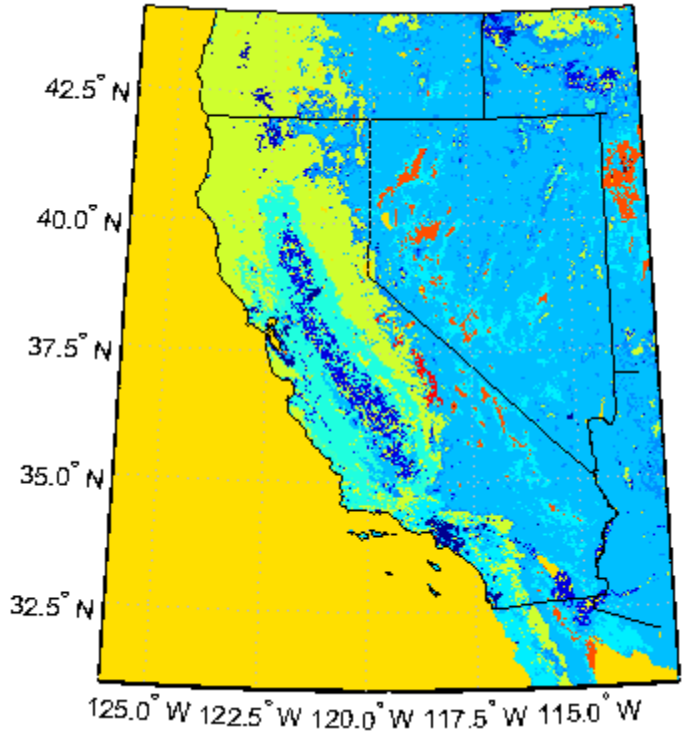
```
[latgrat, longrat, Z] = avhrrgoode('global', ...
   'gusgs2_0g.img',50);

% Convert the geolocated data grid to an geolocated image.
uniqueClasses = unique(Z);
RGB = ind2rgb8(uint8(Z), jet(numel(uniqueClasses)));

% Display the data as an image using the Goode projection.
origin = [0 0 0];
ellipsoid = [6370997 0];
figure('Renderer','zbuffer')
axesm('MapProjection', 'goode', 'Origin', origin, ...
   'Geoid', ellipsoid)
geoshow(latgrat, longrat, RGB, 'DisplayType', 'image');
axis image off

% Plot the coastlines.
hold on
load coast
plotm(lat,long)
```



Example 2 — Classified GLCC Data for California

Read and display every point from the Global Land Cover Characteristics (GLCC) file covering California with the USGS classification scheme, named `nausgs1_2g.img`. You must first download the file to run this example.

```
figure
usamap california
mstruct = gcm;
latlim = mstruct.maplatlimit;
lonlim = mstruct.maplonlimit;
scalefactor = 1;
[latgrat, longrat, Z] = ...
   avhrrgoode('na', 'nausgs1_2g.img', scalefactor, latlim, lonlim);
geoshow(latgrat, longrat, Z, 'DisplayType', 'texturemap');

% Overlay vector data from usastatehi.shp.
california = shaperead('usastatehi', 'UseGeoCoords', true,...
   'BoundingBox', [lonlim;latlim]);
geoshow([california.Lat], [california.Lon], 'Color', 'black');
```



See Also avhrrlambert

Purpose

Read AVHRR data product stored in eqaazim projection

Syntax

```
[latgrat,longrat,Z] = avhrrlambert(region,filename)
[...] = avhrrlambert(region,filename, scalefactor)
[...] = avhrrlambert(region,filename, scalefactor, latlim,
   lonlim)
[...] = avhrrlambert(region,filename, scalefactor, latlim,
   lonlim, gsize)
[...] = avhrrlambert(region,filename, scalefactor, latlim,
   lonlim, gsize,precision)
```

Description

`[latgrat,longrat,Z] = avhrrlambert(region,filename)` reads data from an Advanced Very High Resolution Radiometer (AVHRR) data set with a nominal resolution of 1 km that is stored in the Lambert Equal Area Azimuthal projection. Data of this type includes the Global Land Cover Characteristics (GLCC). *region* specifies the coverage of the file. Valid regions are listed in the following table. *filename* is a string specifying the name of the data file. `Z` is a geolocated data grid with coordinates `latgrat` and `longrat` in units of degrees. A scale factor of 100 is applied to the original data set such that `Z` contains every 100th point in both X and Y.

Region Specifiers
`'a'` or `'asia'`
`'af'` or `'africa'`
`'ap'` or `'australia/pacific'`
`'e'` or `'europe'`
`'na'` or `'north america'`
`'sa'` or `'south america'`

`[...] = avhrrlambert(region,filename, scalefactor)` uses the integer `scalefactor` to downsample the data. A scale factor of 1 returns every point. A scale factor of 10 returns every 10th point. The default value is 100.

`[...] = avhrrlambert(`*`region`*`,`*`filename`*`, scalefactor, latlim, lonlim)` returns data for the specified region. The result may extend somewhat beyond the requested area. The limits are two-element vectors in units of degrees, with `latlim` in the range `[-90 90]` and `lonlim` in the range `[-180 180]`. If `latlim` and `lonlim` are empty, the entire area covered by the data file is returned. If the quadrangle defined by `latlim` and `lonlim` (when projected to form a polygon in the appropriate Lambert Equal Area Azimuthal projection) fails to intersect the bounding box of the data in the projected coordinates, then `latgrat`, `longrat`, and `Z` are empty.

`[...] = avhrrlambert(`*`region`*`,`*`filename`*`, scalefactor, latlim, lonlim, gsize)` controls the size of the graticule matrices. `gsize` is a two-element vector containing the number of rows and columns desired. If omitted or empty, a graticule the size of the grid is returned.

`[...] = avhrrlambert(`*`region`*`,`*`filename`*`, scalefactor, latlim, lonlim, gsize,`*`precision`*`)` reads a data set with the integer *`precision`* specified. If omitted, `'uint8'` is assumed. `'uint16'` is appropriate for some files. Check the metadata (`.txt` or README) file in the ftp folder for specification of the file format and contents.

Background

The United States plans to build a family of satellite-based sensors to measure climate change under the Earth Observing System (EOS) program. Early precursors to the EOS data are the data sets produced by NOAA and NASA under the Pathfinder program. These are data derived from the Advanced High Resolution Radiometer sensor flown on the NOAA Polar Orbiter satellites, NOAA-7, -9, and -11 with a spatial resolution of about 1 km. The data from the AVHRR sensor is processed into separate land, sea, and atmospheric indices. Land area data is processed to a nondimensional vegetation index or land cover classification and stored in binary files in the Plate Carrée, Goode, and Lambert Equal Area Azimuthal projections. Sea data is processed to surface temperatures and stored in HDF formats. This function reads land cover data for the continents saved in the Lambert Equal Area Azimuthal projection at 1 km.

Tips

This function reads the binary files as is. You should not use byte-swapping software on these files.

The AVHRR project and data sets are described in and provided by various U.S. Government Web sites.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: http://www.mathworks.com/help/map/finding-geospatial-data.html .

Examples

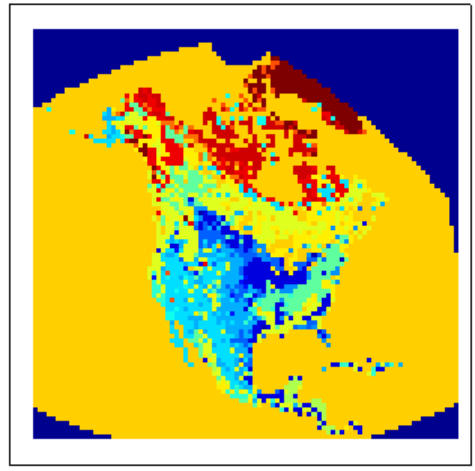
Example 1

Read and display every 100th point from the Global Land Cover Characteristics (GLCC) file covering North America with the USGS classification scheme, named `nausgs1_2l.img`.

```
[latgrat, longrat, Z] = avhrrlambert('na','nausgs1_2l.img');
```

Display the data using the Lambert Equal Area Azimuthal projection.

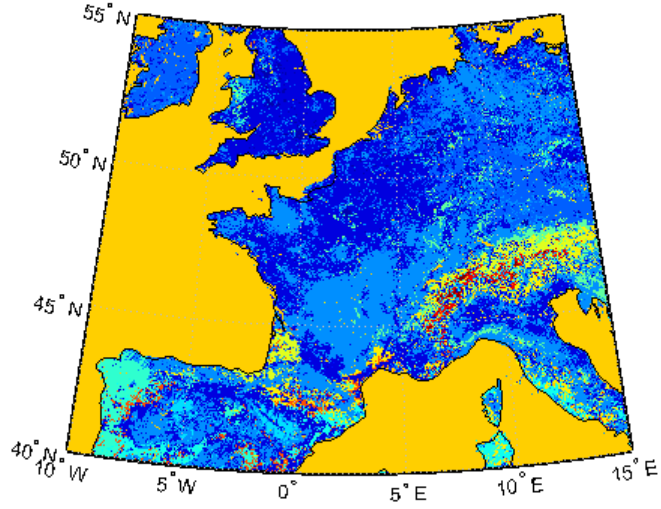
```
origin = [50 -100 0];
ellipsoid = [6370997 0];
figure
axesm('MapProjection', 'eqaazim', 'Origin', ...
   origin, 'Geoid', ellipsoid)
geoshow(latgrat, longrat, Z, 'DisplayType', 'texturemap');
```



Example 2

Read and display every other point from the Global Land Cover Characteristics (GLCC) file covering Europe with the USGS classification scheme, named `eausgs1_2le.img`.

```
figure
worldmap france
mstruct = gcm;
latlim = mstruct.maplatlimit;
lonlim = mstruct.maplonlimit;
scalefactor = 2;
[latgrat, longrat, Z] = avhrrlambert('e', 'eausgs1_2le.img', ...
   scalefactor, latlim, lonlim);
geoshow(latgrat, longrat, Z, 'DisplayType', 'texturemap');
geoshow('landareas.shp','FaceColor','none','EdgeColor','black')
```



See Also

avhrrgoode

axes2ecc

Purpose

Eccentricity of ellipse from axes lengths

Syntax

```
ecc = axes2ecc(semimajor,semiminor)
ecc = axes2ecc(vec)
```

Description

`ecc = axes2ecc(semimajor,semiminor)` computes the eccentricity of an ellipse (or ellipsoid of revolution) given the semimajor and semiminor axes. The input data can be scalar or matrices of equal dimensions.

`ecc = axes2ecc(vec)` assumes a 2 element vector (vec) is supplied, where `vec` = [`semimajor semiminor`].

See Also

`ecc2flat` | `ecc2n` | `majaxis` | `minaxis`

Purpose

Define map axes and set map properties

Syntax

```
axesm
axesm(PropertyName,PropertyValue,...)
axesm(projid,PropertyName,PropertyValue,...)
```

Description

`axesm` with no input arguments, initiates the `axesmui` map axes graphical user interface, which can be used to set map axes properties. This is detailed on the `axesmui` reference page.

`axesm(PropertyName,PropertyValue,...)` creates a map axes using the specified properties. Properties may be specified in any order, but the `MapProjection` property must be included.

`axesm(projid,PropertyName,PropertyValue,...)` uses the string `projid` to designate which map projection to use. `projid` should match one of the entries in the last column displayed by the `maps` function. You can also find a list of these strings in the User's Guide section "Summary and Guide to Projections".

The `axesm` function creates a map axes into which both vector and raster geographic data can be projected using functions such as `plotm` and `geoshow`. Properties specific to map axes can be assigned upon creation with `axesm`, and for an existing map axes they can be queried and changed using `getm` and `setm`. Use the standard `get` and `set` methods to query and control the standard MATLAB® axes properties of a map axes.

Axes Definition

Map axes are standard MATLAB axes with different default settings for some properties and a MATLAB structure for storing projection parameters and other data. The main differences in default settings are

- Axes properties `XGrid`, `YGrid`, `XTick`, `YTick` are set to `'off'`.
- The properties `XColor`, `YColor`, and `ZColor` are set to the background color.
- The `hold` mode is `'on'`.

The map projection structure stores the map axes properties, which, in addition to the special standard axes settings described here, allow Mapping Toolbox functions to recognize an axes or an opened FIG-file as a map axes. See "Map Axes Object Properties" on page 3-51, below, for descriptions of the map axes properties.

Note In general, after re-opening a saved figure that contains a map axes, you should not attempt to modify the projection properties of that map axes.

Note When you create a map axes with `axesm` and right click in the axes, a context menu appears. If you do not need the menu or it interferes with your application, you can disable it by resetting the `'ButtonDownFcn'` property of the axes:

```
ax = axesm('mercator');     % Right-clicking brings up context menu.
set(ax,'ButtonDownFcn',[])  % Context menu has been disabled.
```

Examples

Create map axes for a Mercator projection, with selected latitude limits:

```
axesm('MapProjection','mercator','MapLatLimit',[-70 80])
```

In the preceding example, all properties not explicitly addressed in the call are set to either fixed or calculated defaults. The file `mercator.m` defines a projection function, so the same result could have been achieved with the function

```
axesm('mercator','MapLatLimit',[-70 80])
```

Each projection function includes default values for all properties. Any following property name/property value pairs are treated as overrides.

In either of the above examples, data displayed in the given map axes is in a Mercator projection. Any data falling outside the prescribed limits is not displayed.

Note The names of projection files are case sensitive. The projection files included in Mapping Toolbox software use only lowercase letters and Arabic numerals.

Map Axes Object Properties

- "Properties That Control the Map Projection" on page 3-51
- "Properties That Control the Frame" on page 3-56
- "Properties That Control the Grid" on page 3-59
- "Properties That Control Grid Labeling" on page 3-62

Properties That Control the Map Projection

`AngleUnits`
`{degrees} | radians`

Angular unit of measure — Controls the units of measure used for angles (including latitudes and longitudes) in the map axes. All input data are assumed to be in the given units; `'degrees'` is the default. For more information on angle units, see "Working with Angles: Units and Representations" in the *Mapping Toolbox User's Guide*.

`Aspect`
`{normal} | transverse`

Display aspect — Controls the orientation of the base projection of the map. When the aspect is `'normal'` (the default), *north* in the base projection is up. In a `transverse` aspect, north is to the right. A cylindrical projection of the whole world would look like a *landscape* display under a `'normal'` aspect, and like a *portrait* under a `'transverse'` aspect. Note that this property is not

the same as projection aspect, which is controlled by the `Origin` property vector discussed later.

`FalseEasting`
`scalar {0}`

Coordinate shift for projection calculations — Modifies the position of the map within the axes. The projected coordinates are shifted in the *x*-direction by the amount of `FalseEasting`. The `FalseEasting` is in the same units as the projected coordinates, that is, the units of the first element of the `Geoid` map axes property. False eastings and northings are sometimes used to ensure nonnegative values of the projected coordinates. For example, the Universal Transverse Mercator uses a false easting of 500,000 meters.

`FalseNorthing`
`scalar {0}`

Coordinate shift for projection calculations — Modifies the position of the map within the axes. The projected coordinates are shifted in the *y*-direction by the amount of `FalseNorthing`. The `FalseNorthing` is in the same units as the projected coordinates, that is, the units of the first element of the `Geoid` map axes property. False eastings and northings are sometimes used to ensure nonnegative values of the projected coordinates. For example, the Universal Transverse Mercator uses a false northing of 0 in the northern hemisphere and 10,000,000 meters in the southern.

`FixedOrient`
`scalar {[]} (read-only)`

Projection-based orientation — This read-only property fixes the orientation of certain projections (such as the Cassini and Wetch). When empty, which is true for most projections, the user can alter the orientation of the projection using the third element of the `Origin` property. When fixed, the fixed orientation is always used.

`Geoid`

`[semimajor_axis eccentricity]` or spheroid object

Reference spheroid definition — The spheroid (ellipsoid or sphere) for calculating the projections of any displayed map objects. It can be an `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form [semimajor_axis eccentricity]. The default value is an ellipsoid vector representing the unit sphere: [1 0].

`MapLatLimit`

`[southern_limit northern_limit]`

Geographic latitude limits of the display area — Expressed as a two element vector of the form `[southern_limit northern_limit]`. This property can be set for many typical projections and geometries, but cannot be used with oblique projections or with `globe`, for example. When applicable, the `MapLatLimit` property may affect the origin latitude if the `Origin` property is not set explicitly when calling `axesm`. It may also determine the value used for `FLatLimit`. See "Accessing and Manipulating Map Axes Properties" for a more complete description of the applicability of `MapLatLimit` and its interaction with the origin, frame limits, and other properties.

`MapLonLimit`

`[western_limit eastern_limit]`

Geographic longitude limits of the display area — Expressed as a two element vector of the form `[western_limit eastern_limit]`. This property can be set for many typical projections and geometries, but cannot be used with oblique projections or with `globe`, for example. When applicable, the `MapLonLimit` property may affect the origin longitude if the `Origin` property is not set explicitly when calling `axesm`. It may also determine the value used for `FLonLimit`. See "Accessing and Manipulating Map Axes Properties" for a more complete description of the applicability of

`MapLonLimit` and its interaction with the origin, frame limits, and other properties.

`MapParallels`
`[lat] | [lat1 lat2]`

Projection standard parallels — Sets the standard parallels of projection. It can be an empty, one-, or two-element vector, depending upon the projection. The elements are in the same units as the map axes `AngleUnits`. Many projections have specific, defining standard parallels. When a map axes object is based upon one of these projections, the parallels are set to the appropriate defaults. For conic projections, the default standard parallels are set to 15ºN and 75ºN, which biases the projection toward the northern hemisphere.

For projections with one defined standard parallel, setting the parallels to an empty vector forces recalculation of the parallel to the middle of the map latitude limits. For projections requiring two standard parallels, setting the parallels to an empty vector forces recalculation of the parallels to one-sixth the distance from the latitude limits (e.g., if the map latitude limits correspond to the northern hemisphere `[0 90]`, the standard parallels for a conic projection are set to `[15 75]`). For azimuthal projections, the `MapParallels` property always contains an empty vector and cannot be altered.

See the *Mapping Toolbox User's Guide* for more information on standard parallels.

`MapProjection`
`projection_name` `{no default}`

Map projection — Sets the projection, and hence all transformation calculations, for the map axes object. It is required in the creation of map axes. It must be a member of the recognized projection set, which you can list by typing `getm('MapProjection')` or `maps`. For more information on projections, see the *Mapping Toolbox*

User's Guide. Some projections set their own defaults for other properties, such as parallels and trim limits.

`Origin`

`[latitude longitude orientation]`

Origin and orientation for projection calculations — Sets the map origin for all projection calculations. The latitude, longitude, and orientation should be in the map axes `AngleUnits`. Latitude and longitude refer to the coordinates of the map origin; orientation refers to an angle of skewness or rotation about the axis running through the origin point and the center of the earth. The default origin is 0º latitude and a longitude centered between the map longitude limits. If a scalar is entered, it is assumed to refer to the longitude; if a two-element vector is entered, the default orientation is 0º, a normal projection. If an empty origin vector is entered, the origin is centered on the map longitude limits. For more information on the origin, see the *Mapping Toolbox User's Guide*.

`Parallels`

`0, 1, or 2 (read-only, projection-dependent)`

Number of standard parallels — This read-only property contains the number of standard parallels associated with the projection. See the *Mapping Toolbox User's Guide* for more information on standard parallels.

`ScaleFactor`

`scalar {1}`

Scale factor for projection calculations — Modifies the size of the map in projected coordinates. The geographic coordinates are transformed to Cartesian coordinates by the map projection equations and multiplied by the scale factor. Scale factors are sometimes used to minimize the scale distortion in a map projection. For example, the Universal Transverse Mercator uses

a scale factor of 0.996 to shift the line of zero scale distortion to two lines on either side of the central meridian.

`Zone`

`ZoneSpec | {[] or 31N}`

Zone for certain projections — Specifies the zone for certain projections. A zone is a region on the globe that has a special set of projection parameters. In the Universal Transverse Mercator Projection, the world is divided into quadrangles that are generally 6 degrees wide and 8 degrees tall. The number in the zone designation refers to the longitude range, while the letter refers to the latitude range. Most projections use the same parameters for the entire globe, and do not require a zone.

Properties That Control the Frame

`Frame`

`on | {off}`

Frame visibility — Controls the visibility of the display frame box. When the frame is `'off'` (the default), the frame is not displayed. When the frame is `'on'`, an enclosing frame is visible. The frame is a patch that is plotted as the lowest layer of displayed map objects. Regardless of its display status, the frame always operates in terms of trimming map data.

`FFill`

`scalar plotting point density` `{100}`

Frame plotting precision — Sets the number of points to be used in plotting the frame for display. The default value is `100`, which for a rectangular frame results in a plot with `100` points for each side, or a total of `400` points. The number of points required for a reasonable display varies with the projection. Cylindrical projections such as the Miller require very few. Projections resulting in more complex frames, such as the Werner, look better with higher densities. The default value is generally sufficient.

`FEdgeColor`
`ColorSpec | {[0 0 0]}`

Color of the displayed frame edge — Specifies the color used for the displayed frame. You can specify a color using a vector of RGB values or a MATLAB `colorspec` name. By default, the frame edge is displayed in black (`[0 0 0]`).

`FFaceColor`
`ColorSpec | {none}`

Color of the displayed frame face — Specifies the color used for the displayed frame face. You can specify a color using a vector of RGB values or a MATLAB `colorspec` name. By default, the frame face is `'none'`, meaning no face color is filled in. Another useful color is `'cyan'` (`[0 1 1]`), which looks like water.

`FLatLimit`
`[southern_limit northern_limit]`

Latitude limits of map frame relative to projection origin — The map frame encloses the area in which data and graticule lines are plotted and beyond which they are trimmed. For non-oblique and non-azimuthal projections, which have quadrangular frames, this property controls the north-south extent of the frame. If a projection is made oblique by the inclusion of a non-zero rotation angle (the third element of the `Origin` vector), `FLatLimit` still applies, but in the rotated latitude-longitude system rather than in the geographic system. In the case of azimuthal projections, which have circular frames, `FLatLimit` takes the special form `[-Inf radius]` where radius is the spherical distance (in degrees or radians, depending on the `AngleUnits` property of the projection) from the projection origin to the edge of the frame.

Note In most common situations, including non-oblique cylindrical and conic projections and polar azimuthal projections, there is no need to set `FLatLimit`; use `MapLatLimit` instead.

`FLineWidth`
`scalar` {2}

Frame edge line width — Sets the line width of the displayed frame edge. The value is a scalar representing points, which is 2 by default.

`FLonLimit`
`[western_limit eastern_limit]`

Latitude limits of map frame relative to projection origin — The map frame encloses the area in which data and graticule lines are plotted and beyond which they are trimmed. For non-oblique and non-azimuthal projections, which have quadrangular frames, this property controls the east-west extent of the frame. If a projection is made oblique by the inclusion of a non-zero rotation angle (the third element of the `Origin` vector), `FLonLimit` still applies, but in the rotated latitude-longitude system rather than in the geographic system. The `FLonLimit` property is ignored for azimuthal projections.

Note In most common situations, including non-oblique cylindrical and conic projections, there is no need to set `FLonLimit`; use `MapLonLimit` instead.

`TrimLat`
`[southern_limit northern_limit]`
`(read-only, projection-dependent)`

Bounds on `FLatLimit` — This read-only property sets bounds on the values that `axesm` and `setm` will accept for the `MapLatLimit` and `FLatLimit` properties, which is necessary because some map projections cannot display the entire globe without extending to infinity. For example, `TrimLat` is `[-90 90]` degrees for most cylindrical projections and `[-86 86]` degrees for the Mercator projection because the north-south scale becomes infinite as one approaches either pole.

`TrimLon`

```
[western_limit eastern_limit]
(read-only, projection-dependent)
```

Bounds on `FLonLimit` — This read-only property sets bounds on the values that `axesm` and `setm` will accept for the `MapLonLimit` and `FLonLimit` properties, which is necessary because some map projections cannot display the entire globe without extending to infinity. For example, `TrimLon` is `[-135 135]` degrees for most conic projections.

Properties That Control the Grid

`Grid`

```
on | {off}
```

Grid visibility — Controls the visibility of the display grid. When the grid is `'off'` (the default), the grid is not displayed. When the grid is `'on'`, meridians and parallels are visible. The grid is plotted as a set of line objects.

`GAltitude`

```
scalar z-axis value {Inf}
```

Grid z-axis setting — Sets the *z*-axis location for the grid when displayed. Its default value is infinity, which is displayed above all other map objects. However, you can set this to some other value for stacking objects above the grid, if desired.

`GColor`
`ColorSpec | {[0 0 0]}`

Color of the displayed grid — Specifies the color used for the displayed grid. You can specify a color using a vector of RGB values or one of the MATLAB `colorspec` names. By default, the map grid is displayed in black (`[0 0 0]`).

`GLineStyle`
`LineStyle {:}`

Grid line style — Determines the style of line used when the grid is displayed. You can specify any line style supported by the MATLAB `line` function. The default line style is a dotted line (that is, `':'`).

`GLineWidth`
`scalar {0.5}`

Grid line width — Sets the line width of the displayed grid. The value is a scalar representing points, which is `0.5` by default.

`MLineException`
`vector of longitudes {[]}`

Exceptions to grid meridian limits — Allows specific meridians of the displayed grid to extend beyond the grid meridian limits to the poles. The value must be a vector of longitudes in the appropriate angle units. For longitudes so specified, grid lines extend from pole to pole regardless of the existence of any grid meridian limits. This vector is empty by default.

`MLineFill`
`scalar plotting point density {100}`

Grid meridian plotting precision — Sets the number of points to be used in plotting the grid meridians. The default value is 100 points. The number of points required for a reasonable display varies with the projection. Cylindrical projections such as the

Miller require very few. Projections resulting in more complex shapes, such as the Werner, look better with higher densities. The default value is generally sufficient.

`MLineLimit`

`[north south] | [south north] {[]}`

Grid meridian limits — Establishes latitudes beyond which displayed grid meridians do not extend. By default, this property is empty, so the meridians extend to the poles. There are two exceptions to the meridian limits. No meridian extends beyond the map latitude limits, and exceptions to the meridian limits for selected meridians are allowed (see above).

`MLineLocation`

`scalar interval or specific vector {30°}`

Grid meridian interval or specific locations — Establishes the interval between displayed grid meridians. When a scalar interval is entered in the map axes `MLineLocation`, meridians are displayed, starting at 0° longitude and repeating every interval in both directions, which by default is 30°. Alternatively, you can enter a vector of longitudes, in which case a meridian is displayed for each element of the vector.

`PLineException`

`vector of latitudes {[]}`

Exceptions to grid parallel limits — Allows specific parallels of the displayed grid to extend beyond the grid parallel limits to the International Date Line. The value must be a vector of latitudes in the appropriate angle units. For latitudes so specified, grid lines extend from the western to the eastern map limit, regardless of the existence of any grid parallel limits. This vector is empty by default.

`PLineFill`

`scalar plotting point density {100}`

Grid parallel plotting precision — Sets the number of points to be used in plotting the grid parallels. The default value is `100`. The number of points required for a reasonable display varies with the projection. Cylindrical projections such as the Miller require very few. Projections resulting in more complex shapes, such as the Bonne, look better with higher densities. The default value is generally sufficient.

`PLineLimit`
`[east west] | [west east] {[]}`

Grid parallel limits — Establishes longitudes beyond which displayed grid parallels do not extend. By default, this property is empty, so the parallels extend to the date line. There are two exceptions to the parallel limits. No parallel extends beyond the map longitude limits, and exceptions to the parallel limits for selected parallels are allowed (see above).

`PLineLocation`
`scalar interval or specific vector {15°}`

Grid parallel interval or specific locations — Establishes the interval between displayed grid parallels. When a scalar interval is entered in the map axes `PLineLocation`, parallels are displayed, starting at 0° latitude and repeating every interval in both directions, which by default is 15°. Alternatively, you can enter a vector of latitudes, in which case a parallel is displayed for each element of the vector.

Properties That Control Grid Labeling

`FontAngle`
`{normal} | italic | oblique`

Select italic or normal font for all grid labels — Selects the character slant for all displayed grid labels. `'normal'` specifies nonitalic font. `'italic'` and `'oblique'` specify italic font.

`FontColor`

`ColorSpec | {black}`

Text color for all grid labels — Sets the color of all displayed grid labels. `ColorSpec` is a three-element vector specifying an RGB triple or a predefined MATLAB color string (`colorspec`).

`FontName`

`courier | {helvetica} | symbol | times`

Font family name for all grid labels — Sets the font for all displayed grid labels. To display and print properly, `FontName` must be a font that your system supports.

`FontSize`

`scalar in units specified in FontUnits {9}`

Font size — An integer specifying the font size to use for all displayed grid labels, in units specified by the `FontUnits` property. The default point size is 9.

`FontUnits`

`{points} | normalized | inches | centimeters | pixels`

Units used to interpret the FontSize property — When set to `normalized`, the toolbox interprets the value of `FontSize` as a fraction of the height of the axes. For example, a normalized `FontSize` of `0.1` sets the text characters to a font whose height is one-tenth of the axes' height. The default units (`points`) are equal to `1/72` of an inch.

`FontWeight`

`bold | {normal}`

Select bold or normal font — The character weight for all displayed grid labels.

`LabelFormat`

`{compass} | signed | none`

Labeling format for grid — Specifies the format of the grid labels. If `'compass'` is employed (the default), meridian labels are suffixed with an "E" for east and a "W" for west, and parallel labels are suffixed with an "N" for north and an "S" for south. If `'signed'` is used, meridian labels are prefixed with a "+" for east and a "-" for west, and parallel labels are suffixed with a "+" for north and a "-" for south. If `'none'` is selected, straight latitude and longitude numerical values are employed, so western meridian labels and southern parallel labels will have a "-", but no symbol precedes eastern and northern (positive) labels.

`LabelRotation`

```
on | {off}
```

Label Rotation — Determines whether the meridian and parallel labels are displayed without rotation (the default) or rotated to align to the graticule. This option is not available for the Globe display.

`LabelUnits`

```
{degrees} | dm | dms | radians
```

Specify units and formatting for grid labels — The display of meridian and parallel labels is controlled by the map axes `LabelUnits` property, as described in the following table.

LabelUnits value	Label format
`'degrees'`	decimal degrees
`'dm'`	degrees/decimal minutes
`'dms'`	degrees/minutes/decimal seconds
`'radians'`	decimal radians

`LabelUnits` does not have a default of its own; instead it defaults to the value of `AngleUnits` at the time the map axes is constructed, which itself defaults to degrees. Although you can specify `'dm'` and `'dms'` for `LabelUnits`, these values are not accepted when setting `AngleUnits`.

`MeridianLabel`
`on | {off}`

Toggle display of meridian labels — Specifies whether the meridian labels are visible or not.

`MLabelLocation`
`scalar interval or vector of longitudes`

Specify meridians for labeling — Meridian labels need not coincide with the displayed meridian lines. Labels are displayed at intervals if a scalar in the map axes `MLabelLocation` is entered, starting at the prime meridian and repeating at every interval in both directions. If a vector of longitudes is entered, labels are displayed at those meridians. The default locations coincide with the displayed meridian lines, as specified in the `MLineLocation` property.

`MLabelParallel`
`{north} | south | equator | scalar latitude`

Specify parallel for meridian label placement — Specifies the latitude location of the displayed meridian labels. If a latitude is specified, all meridian labels are displayed at that latitude. If `'north'` is specified, the maximum of the `MapLatLimit` is used; if `'south'` is specified, the minimum of the `MapLatLimit` is used. If `'equator'` is specified, a latitude of 0^{o} is used.

`MLabelRound`
`integer scalar {0}`

Specify significant digits for meridian labels — Specifies to which power of ten the displayed labels are rounded. For example, if `MLabelRound` is -1, labels are displayed down to the *tenths*. The default value of `MLabelRound` is 0; that is, displayed labels have no decimal places, being rounded to the *ones* column (10^{0}).

`ParallelLabel`
`on | {off}`

Toggle display of parallel labels — Specifies whether the parallel labels are visible or not.

`PLabelLocation`
`scalar interval or vector of latitudes`

Specify parallels for labeling — Parallel labels need not coincide with the displayed parallel lines. Labels are displayed at intervals if a scalar in the map axes `PLabelLocation` is entered, starting at the equator and repeating at every interval in both directions. If a vector of latitudes is entered, labels are displayed at those parallels. The default locations coincide with the displayed parallel lines, as specified in the `PLineLocation` property.

`PLabelMeridian`
`east | {west} | prime | scalar longitude`

Specify meridian for parallel label placement — Specifies the longitude location of the displayed parallel labels. If a longitude is specified, all parallel labels are displayed at that longitude. If `'east'` is specified, the maximum of the `MapLonLimit` is used; if `'west'` is specified, the minimum of the `MapLonLimit` is used. If `'prime'` is specified, a longitude of 0^o is used.

`PLabelRound`
`integer scalar {0}`

Specify significant digits for parallel labels — Specifies to which power of ten the displayed labels are rounded. For example, if `PLabelRound` is -1, labels are displayed down to the tenths. The default value of `PLabelRound` is 0; that is, displayed labels have no decimal places, being rounded to the ones column (10^0).

See Also

`axes | gcm | getm | setm`

Purpose

Resize axes for equivalent scale

Syntax

```
axesscale
axesscale(hbase)
axesscale(hbase,hother)
```

Description

`axesscale` resizes all axes in the current figure to have the same scale as the current axes (`gca`). In this context, scale means the relationship between axes *x*- and *y*-coordinates and figure and paper coordinates. When `axesscale` is used, a unit of length in *x* and *y* is printed and displayed at the same size in all the affected axes. The `XLimMode` and `YLimMode` of the axes are set to `'manual'` to prevent autoscaling from changing the scale.

`axesscale(hbase)` uses the axes `hbase` as the reference axes, and rescales the other axes in the current figure.

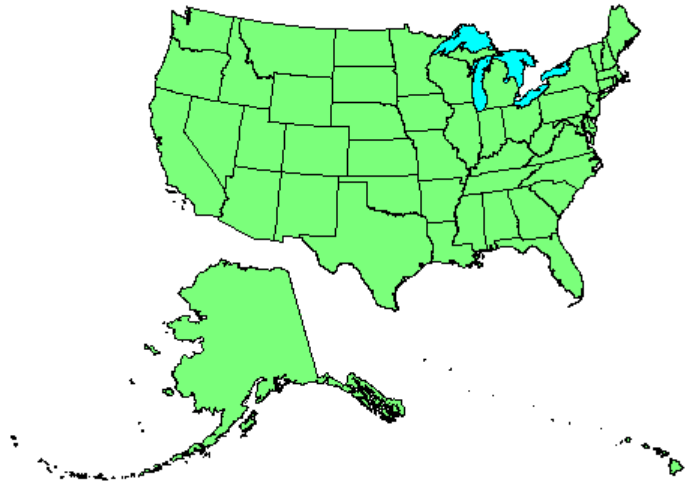
`axesscale(hbase,hother)` uses the axes `hbase` as the base axes, and rescales only the axes in `hother`.

Examples

Display the conterminous United States, Alaska, and Hawaii in separate axes in the same figure, with a common scale.

```
% Read state names and coordinates, extract Alaska and Hawaii
states = shaperead('usastatehi', 'UseGeoCoords', true);
statenames = {states.Name};
alaska = states(strcmp('Alaska', statenames));
hawaii = states(strcmp('Hawaii', statenames));

% Create a figure for the conterminous states
f1 = figure; hconus = usamap('conus'); tightmap
geoshow(states, 'FaceColor', [0.5 1 0.5]);
framem off; gridm off; mlabel off; plabel off
load conus gtlakelat gtlakelon
geoshow(gtlakelat, gtlakelon,...
  'DisplayType', 'polygon', 'FaceColor', 'cyan')
gridm off;
```

```
% Working figure for additional calls to usamap
f2 = figure('Visible','off');

halaska = axes; usamap('alaska'); tightmap;
geoshow(alaska, 'FaceColor', [0.5 1 0.5]);
gridm off;
framem off; mlabel off; plabel off; gridm off;
set(halaska,'Parent',f1)

hhawaii = axes; usamap('hawaii'); tightmap;
geoshow(hawaii, 'FaceColor', [0.5 1 0.5]);
gridm off;
framem off; mlabel off; plabel off; gridm off;
set(hhawaii,'Parent',f1)

close(f2)

% Arrange the axes as desired
set(hconus,'Position',[0.1 0.25 0.85 0.6])
set(halaska,'Position',[0.019531 -0.020833 0.2 0.2])
set(hhawaii,'Position',[0.5 0 .2 .2])

% Resize alaska and hawaii axes
axesscale(hconus)
hidem([halaska hhawaii])
```



Limitations

The equivalence of scales holds only as long as no commands are issued that can change the scale of one of the axes. For example, changing the units of the ellipsoid or the scale factor in one of the axes would change the scale.

Tips

To ensure the same map scale between axes, use the same ellipsoid and scale factors.

See Also

`paperscale`

azimuth

Purpose

Azimuth between points on sphere or ellipsoid

Syntax

```
az = azimuth(lat1,lon1,lat2,lon2)
az = azimuth(lat1,lon1,lat2,lon2,ellipsoid)
az = azimuth(lat1,lon1,lat2,lon2,units)
az = azimuth(lat1,lon1,lat2,lon2,ellipsoid,units)
az = azimuth(track,...)
```

Description

`az = azimuth(lat1,lon1,lat2,lon2)` calculates the great circle azimuth from point 1 to point 2, for pairs of points on the surface of a sphere. The input latitudes and longitudes can be scalars or arrays of matching size. If you use a combination of scalar and array inputs, the scalar inputs will be automatically expanded to match the size of the arrays. The function measures azimuths clockwise from north and expresses them in degrees or radians.

`az = azimuth(lat1,lon1,lat2,lon2,ellipsoid)` computes the azimuth assuming that the points lie on the ellipsoid defined by the input `ellipsoid`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The default ellipsoid is a unit sphere.

`az = azimuth(lat1,lon1,lat2,lon2,units)` uses the input string *`units`* to define the angle units of `az` and the latitude-longitude coordinates. Use `'degrees'` (the default value), in the range from 0 to 360, or `'radians'`, in the range from 0 to 2*pi.

`az = azimuth(lat1,lon1,lat2,lon2,ellipsoid,units)` specifies both the `ellipsoid` vector and the units of `az`.

`az = azimuth(track,...)` uses the input string *`track`* to specify either a great circle or a rhumb line azimuth calculation. Enter `'gc'` for the *`track`* string (the default value), to obtain great circle azimuths for a sphere or geodesic azimuths for an ellipsoid. (Hint to remember string name: the letters “g” and “c” are in both great circle and geodesic.) Enter `'rh'` for the *`track`* string to obtain rhumb line azimuths for either a sphere or an ellipsoid.

Definitions

Azimuth

An *azimuth* is the angle at which a smooth curve crosses a meridian, taken clockwise from north. The North Pole has an azimuth of 0º from every other point on the globe. You can calculate azimuths for great circles or rhumb lines.

Geodesic

A *geodesic* is the shortest distance between two points on a curved surface, such as an ellipsoid.

Great Circle

A *great circle* is a type of geodesic that lies on a sphere. It is the intersection of the surface of a sphere with a plane passing through the center of the sphere. For great circles, the azimuth is calculated at the starting point of the great circle path, where it crosses the meridian. In general, the azimuth along a great circle is not constant.

Rhumb Line

A *rhumb line* is a curve that crosses each meridian at the same angle. For rhumb lines, the azimuth is the *constant* angle between true north and the entire rhumb line passing through the two points.

For more information on the distinction between great circles and rhumb lines, see "Great Circles, Rhumb Lines, and Small Circles" in the *Mapping Toolbox* documentation.

Examples

Find the azimuth between two points on the same parallel, for example, (10ºN, 10ºE) and (10ºN, 40ºE). The azimuth between two points depends on the *`track`* string selected.

```
% Try the 'gc' track string.
az = azimuth('gc',10,10,10,40)

% Compare to the result obtained from the 'rh' track string.
az = azimuth('rh',10,10,10,40)
```

Find the azimuth between two points on the same meridian, say (10ºN, 10ºE) and (40ºN, 10ºE):

```
% Try the 'gc' track string.
az = azimuth(10,10,40,10)

% Compare to the 'rh' track string.
az = azimuth('rh',10,10,40,10)
```

Rhumb lines and great circles coincide along meridians and the Equator. The azimuths are the same because the paths coincide.

Algorithms

Azimuths over Long Geodesics

Azimuth calculations for geodesics degrade slowly with increasing distance and can break down for points that are nearly antipodal or for points close to the Equator. In addition, for calculations on an ellipsoid, there is a small but finite input space. This space consists of pairs of locations in which both points are nearly antipodal *and* both points fall close to (but not precisely on) the Equator. In such cases, you will receive a warning and `az` will be set to NaN for the "problem pairs."

Eccentricity

Geodesic azimuths on an ellipsoid are valid only for small eccentricities typical of the Earth (for example, 0.08 or less).

Alternatives

If you are calculating both the distance and the azimuth, you can call just the `distance` function. The function returns the azimuth as the second output argument. It is unnecessary to call `azimuth` separately.

See Also

`distance` | `elevation` | `reckon` | `track` | `track1` | `track2`

Purpose

Buffer zones for latitude-longitude polygons

Syntax

```
[latb,lonb] = bufferm(lat,lon,bufwidth)
[latb,lonb] = bufferm(lat,lon,bufwidth,direction)
[latb,lonb] = bufferm(lat,lon,dist,direction,npts)
```

Description

`[latb,lonb] = bufferm(lat,lon,bufwidth)` computes the buffer zone around a line or polygon. If the vectors `lat` and `lon`, in units of degrees, define a line, then `latb` and `lonb` define a polygon that contains all the points that fall within a certain distance, `bufwidth`, of the line. `bufwidth` is a scalar specified in degrees of arc along the surface. If the vectors `lat` and `lon` define a polygon, then `latb` and `lonb` define a region that contains all the points exterior to the polygon that fall within `bufwidth` of the polygon.

`[latb,lonb] = bufferm(lat,lon,bufwidth,`*`direction`*`)` uses the optional string *`direction`* to specify whether the buffer zone is inside `'in'`or `'out'` of the polygon. A third option, `'outPlusInterior'`, returns the union of an exterior buffer (as would be computed using `'out'`) with the interior of the polygon. If you do not supply a *`direction`* string, `bufferm` uses `'out'` as the default and returns a buffer zone outside the polygon. If you supply `'in'` as the *`direction`* string, `bufferm` returns a buffer zone inside the polygon. If you are finding the buffer zone around a line, `'out'` is the only valid option.

`[latb,lonb] = bufferm(lat,lon,dist,`*`direction`*`,npts)` controls the number of points used to construct circles about the vertices of the polygon. A larger number of points produces smoother buffers, but requires more time. If `npts` is omitted, 13 points per circle are used.

Tips

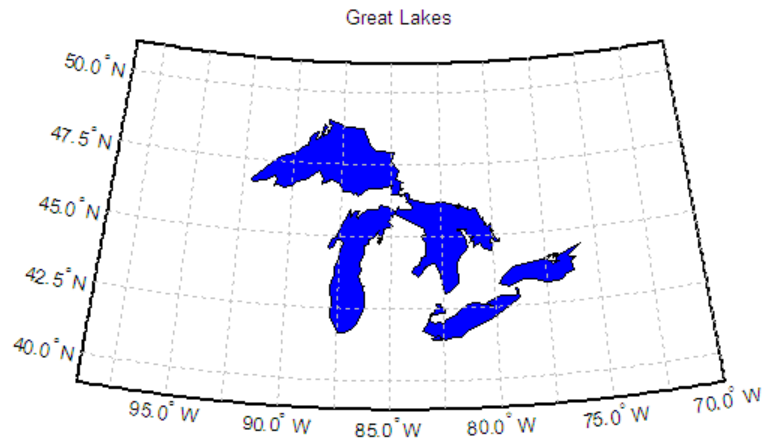
Close all polygons before processing them with `bufferm`. If a polygon is not closed, `bufferm` assumes it is a line.

Examples

Display buffer zones inside and outside the Great Lakes:

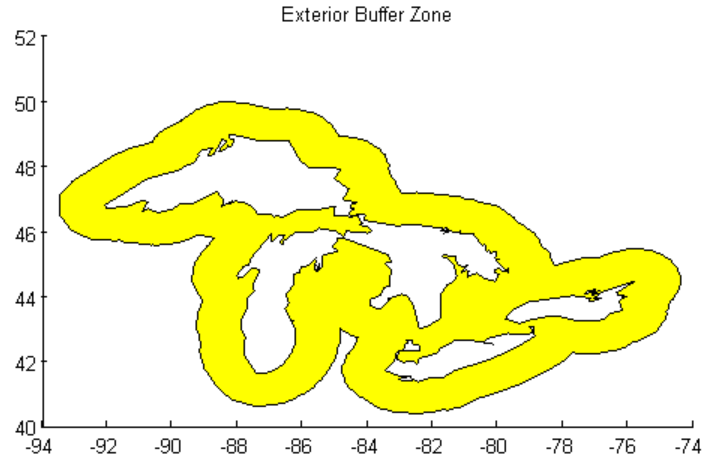
```
% Display a simplified version of the five polygons that
% represent the Great Lakes.
```

```
load conus
tol = 0.05;
[latr, lonr] = reducem(gtlakelat, gtlakelon, tol);
figure('Color','w')
ax = usamap({'MN','NY'});
setm(ax,'MLabelLocation',5)
geoshow(latr, lonr, 'DisplayType', 'polygon', ...
   'FaceColor', 'blue')
title('Great Lakes')
```

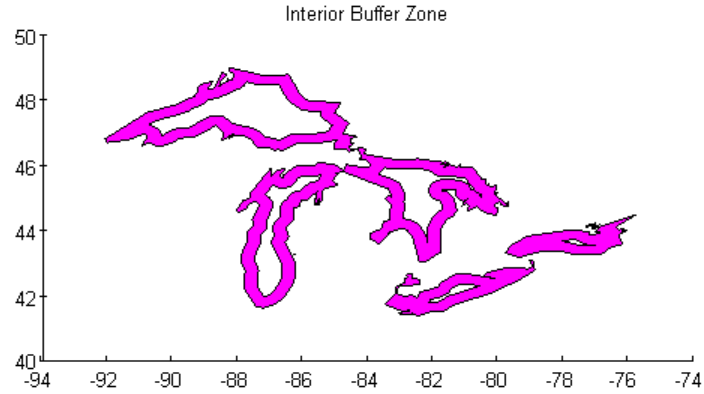



```
% Set the buffer width and display a buffer zone outside
% the lakes.
figure;
bufwidth = 1;
[latb, lonb] = bufferm(latr, lonr, bufwidth);
geoshow(latb, lonb, 'DisplayType', 'polygon', ...
```

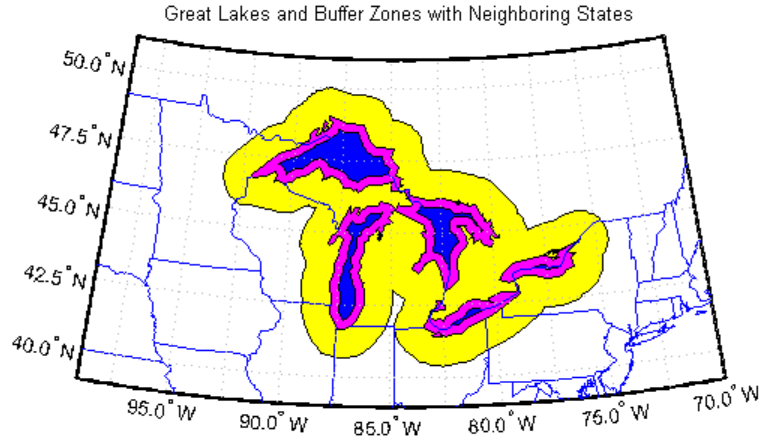
```
   'FaceColor', 'yellow')
title('Exterior Buffer Zone')
```



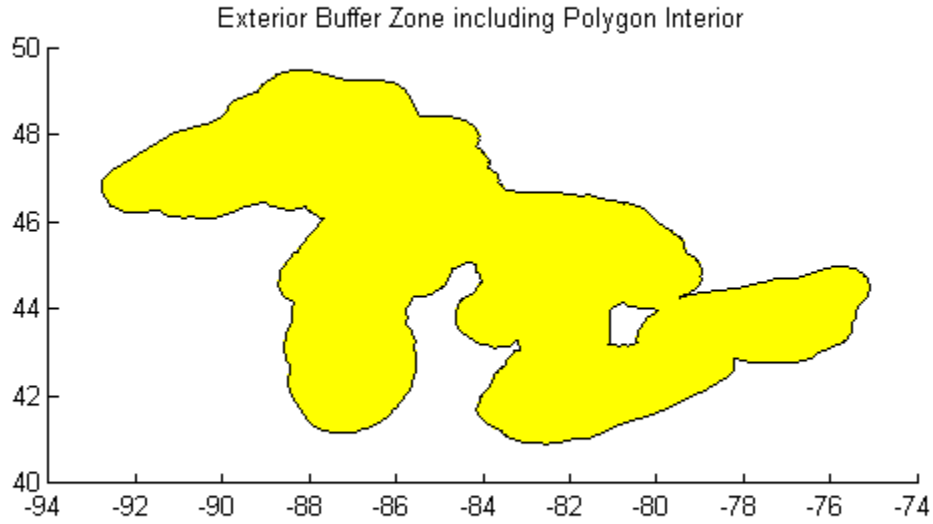

```
% Display a buffer zone inside the polygon.
figure;
[lati, loni] = bufferm(latr, lonr, 0.3*bufwidth, 'in');
geoshow(lati, loni, 'DisplayType', 'polygon', ...
   'FaceColor', 'magenta')
title('Interior Buffer Zone')
```




```
% Display the Great Lakes with interior and exterior
% buffer zones on a backdrop of neighboring states.
figure('Color','w')
ax = usamap({'MN','NY'});
setm(ax,'MLabelLocation',5)
geoshow(latb, lonb, 'DisplayType', 'polygon', 'FaceColor', 'yellow')
geoshow(latr, lonr, 'DisplayType', 'polygon', 'FaceColor', 'blue')
geoshow(lati, loni, 'DisplayType', 'polygon', 'FaceColor', 'magenta')
geoshow(uslat, uslon)
geoshow(statelat, statelon)
title('Great Lakes and Buffer Zones with Neighboring States')
```




```
% Example using 'outPlusInterior' option:
bufWidth = 0.5;
[latz, lonz] = bufferm(latr, lonr, bufWidth,'outPlusInterior');
figure
geoshow(latz,lonz,'DisplayType','polygon','FaceColor','yellow')
title('Exterior Buffer Zone including Polygon Interior');
```



See Also `polybool`

Purpose

Expand limits of geographic quadrangle

Syntax

```
[latlim,lonlim] = bufgeoquad(latlim,lonlim,buflat,buflon)
```

Description

`[latlim,lonlim] = bufgeoquad(latlim,lonlim,buflat,buflon)` returns an expanded version of the geographic quadrangle defined by `latlim` and `lonlim`.

Input Arguments

latlim - Latitude limits

1-by-2 vector

Latitude limits of a geographic quadrangle, specified as a 1-by-2 vector of the form `[southern_limit northern_limit]`, with latitudes in degrees. The two elements must be in ascending order, and lie in the closed interval [-90 90].

Data Types
single | double

lonlim - Latitude limits

1-by-2 vector

Longitude limits of a geographic quadrangle, specified as a 1-by-2 vector of the form `[western_limit eastern_limit]`, with longitudes in degrees. The two limits need not be in numerical ascending order.

Data Types
single | double

buflat - Latitude buffer size

nonnegative scalar

Latitude buffer size, specified as a nonnegative scalar, in units of degrees.

Data Types
double

buflon - Longitude buffer size

nonnegative scalar

Longitude buffer size, specified as a nonnegative scalar, in units of degrees.

Data Types
double

Output Arguments

latlim - Latitude limits

1–by-2 vector

Latitude limits of a geographic quadrangle, returned as a 1-by-2 vector of the form `[southern_limit northern_limit]`, in units of degrees. The elements are in ascending order, and both lie in the closed interval [-90 90].

lonlim - Latitude limits

1–by-2 vector

Longitude limits of a geographic quadrangle, returned as a 1-by-2 vector of the form `[western_limit eastern_limit]`, in units of degrees. The limits are wrapped to the interval [-180 180]. They are not necessarily in numerical ascending order.

Examples

Bounding Quadrangle for U.S.

Bounding quadrangle for the Conterminous United States, buffered 2 degrees to the north and south and 3 degrees to the east and west.

```
conus = load('conus.mat');
[latlim, lonlim] = geoquadline(conus.uslat,conus.uslon);
[latlim,lonlim] = bufgeoquad(latlim,lonlim,2,3)

latlim =

   23.1200   51.3800
```

```
lonlim =

 -127.7200  -63.9700
```

See Also

geoquadpt | geoquadline | outlinegeoquad

camposm

Purpose

Set camera position using geographic coordinates

Syntax

```
camposm(lat,long,alt)
[x,y,z] = camposm(lat,long,alt)
```

Description

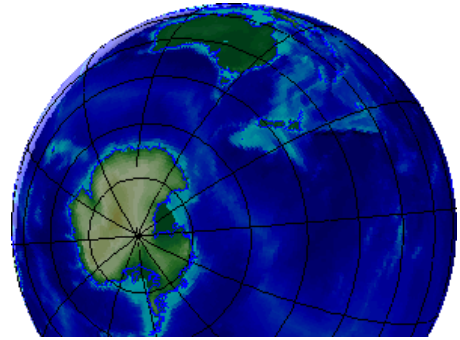
`camposm(lat,long,alt)` sets the axes `CameraPosition` property of the current map axes to the position specified in geographic coordinates. The inputs `lat` and `long` are assumed to be in the angle units of the current map axes.

`[x,y,z] = camposm(lat,long,alt)` returns the camera position in the projected Cartesian coordinate system.

Examples

Look at northern Australia from a point south and one Earth radius above New Zealand:

```
figure
axesm('globe','galt',0)
gridm('glinestyle','-')
load topo
geoshow(topo,topolegend,'DisplayType','texturemap');
demcmap(topo)
camlight;
material(0.6*[ 1 1 1])
plat = -50; plon = 160;
tlat = -10; tlon = 130;
camtargm(tlat,tlon,0);
camposm(plat,plon,1);
camupm(tlat,tlon)
set(gca,'CameraViewAngle',75)
land = shaperead('landareas.shp','UseGeoCoords',true)
linem([land.Lat],[land.Lon])
axis off
```



See Also

camtargm | camupm | campos | camva

camtargm

Purpose

Set camera target using geographic coordinates

Syntax

```
camtargm(lat,long,alt)
[x,y,z] = camtargm(lat,long,alt)
```

Description

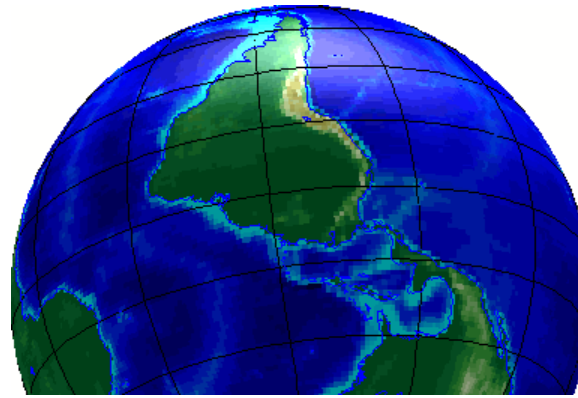
`camtargm(lat,long,alt)` sets the axes `CameraTarget` property of the current map axes to the position specified in geographic coordinates. The inputs `lat` and `long` are assumed to be in the angle units of the current map axes.

`[x,y,z] = camtargm(lat,long,alt)` returns the camera target in the projected Cartesian coordinate system.

Examples

Look down the spine of the Andes from a location three Earth radii above the surface:

```
figure
axesm('globe','galt',0)
gridm('glinestyle','-')
load topo
geoshow(topo,topolegend,'DisplayType','texturemap');
demcmap(topo)
lightm(-80,-180);
material(0.6*[ 1 1 1])
plat = 10; plon = -65;
tlat = -30; tlon = -70;
camtargm(tlat,tlon,0);
camposm(plat,plon,3);
camupm(tlat,tlon);
camva(20)
set(gca,'CameraViewAngle',30)
land = shaperead('landareas.shp','UseGeoCoords',true)
linem([land.Lat],[land.Lon])
axis off
```



See Also

camposm | camupm | camtarget | camva

camupm

Purpose

Set camera up vector using geographic coordinates

Syntax

```
camupm(lat,long)
[x,y,z] = camupm(lat,long)
```

Description

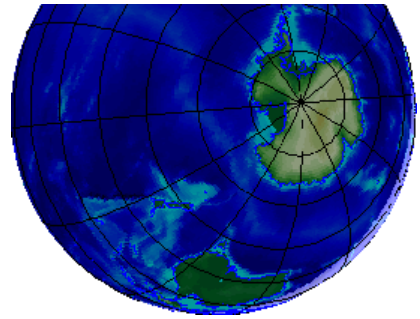
`camupm(lat,long)` sets the axes `CameraUpVector` property of the current map axes to the position specified in geographic coordinates. The inputs `lat` and `long` are assumed to be in the angle units of the current map axes.

`[x,y,z] = camupm(lat,long)` returns the camera position in the projected Cartesian coordinate system.

Examples

Look at northern Australia from a point south of and one Earth radius above New Zealand. Set `CameraUpVector` to the antipode of the camera target for that *down under* view:

```
figure
axesm('globe','galt',0)
gridm('glinestyle','-')
load topo
geoshow(topo,topolegend,'DisplayType','texturemap');
demcmap(topo)
camlight;
material(0.6*[ 1 1 1])
plat = -50; plon = 160;
tlat = -10; tlon = 130;
[alat,alon] = antipode(tlat,tlon);
camtargm(tlat,tlon,0);
camposm(plat,plon,1);
camupm(alat,alon)
set(gca,'CameraViewAngle',80)
land = shaperead('landareas.shp','UseGeoCoords',true)
linem([land.Lat],[land.Lon])
axis off
```



See Also

camtargm | camposm | camup | camva

cart2grn

Purpose

Transform projected coordinates to Greenwich system

Syntax

```
[lat,lon,alt] = cart2grn
[lat,lon,alt] = cart2grn(hndl)
[lat,lon,alt] = cart2grn(hndl,mstruct)
```

Description

When objects are projected and displayed on map axes, they are plotted in Cartesian coordinates appropriate for the selected projection. This function transforms those coordinates back into the Greenwich frame, in which longitude is measured positively East from Greenwich (longitude 0), England and negatively West from Greenwich.

`[lat,lon,alt] = cart2grn` returns the latitude, longitude, and altitude data in geographic coordinates of the current map object, removing any clips or trims introduced during the display process from the output data.

`[lat,lon,alt] = cart2grn(hndl)` specifies the displayed map object desired with its handle `hndl`. The default handle is `gco`.

`[lat,lon,alt] = cart2grn(hndl,mstruct)` specifies the map structure associated with the object. The map structure of the current axes is the default.

See Also

`gcm` | `mfwdtran` | `minvtran` | `project`

Purpose

Substitute values in data array

Syntax

```
mapout = changem(Z,newcode,oldcode)
```

Description

`mapout = changem(Z,newcode,oldcode)` returns a data grid `mapout` identical to the input data grid, except that each element of `Z` with a value contained in the vector `oldcode` is replaced by the corresponding element of the vector `newcode`.

`oldcode` is 0 (scalar) by default, in which case `newcode` must be scalar. Otherwise, `newcode` and `oldcode` must be the same size.

Examples

Invent a map:

```
A = magic(3)

A =
     8     1     6
     3     5     7
     4     9     2
```

Replace instances of 8 or 9 with 0s:

```
B = changem(A,[0 0],[9 8])
B =
     0     1     6
     3     5     7
     4     0     2
```

circcirc

Purpose

Intersections of circles in Cartesian plane

Syntax

```
[xout,yout] = circcirc(x1,y1,r1,x2,y2,r2)
```

Description

`[xout,yout] = circcirc(x1,y1,r1,x2,y2,r2)` finds the points of intersection (if any), given two circles, each defined by center and radius in *x* -*y* coordinates. In general, two points are returned. When the circles do not intersect or are identical, `NaN`s are returned.

When the two circles are tangent, two identical points are returned. All inputs must be scalars.

See Also

`linecirc`

Purpose

Add contour labels to map contour display

Syntax

```
clabelm(c,h)
clabelm(c,h,v)
clabelm(c,h,'manual')
clabelm(c), clabelm(c,v), or clabelm(c,'manual')
clabelm(...,Name,Value)
h = clabelm(...)
```

Description

`clabelm(c,h)` adds value labels to the current map contour plot. The labels are rotated and inserted within the contour lines.

`clabelm(c,h,v)` labels only the contour levels given in vector `v`. (The default action is to label all known contours.) The label positions are selected randomly.

`clabelm(c,h,'manual')` places contour labels at the locations you select by clicking the mouse. Press the **return** key while the cursor is within the figure window to terminate labeling. If no mouse is available, use the space bar to enter contours and the arrow keys to move the crosshair.

`clabelm(c), clabelm(c,v), or clabelm(c,'manual')` uses a different method to indicate the correspondence between labels and contour lines. Use these syntaxes to display an upright label with a plus sign to indicate the relevant contour line.

`clabelm(...,Name,Value)` specifies parameters and corresponding values that control various aspects of the `clabelm` function. Parameter names can be abbreviated, and case does not matter.

`h = clabelm(...)` returns handles to the `text` objects created.

Input Arguments

c

Contour matrix returned by `contourm`, `contourfm`, or `contour3m`

h

Object handle returned by `contourm`, `contourfm`, or `contour3m`

v

Vector

'manual'

String specifying manual placement of contour labels

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

LabelSpacing

Specifies the spacing between labels on the same contour line, in units of points. (72 points equal one inch.)

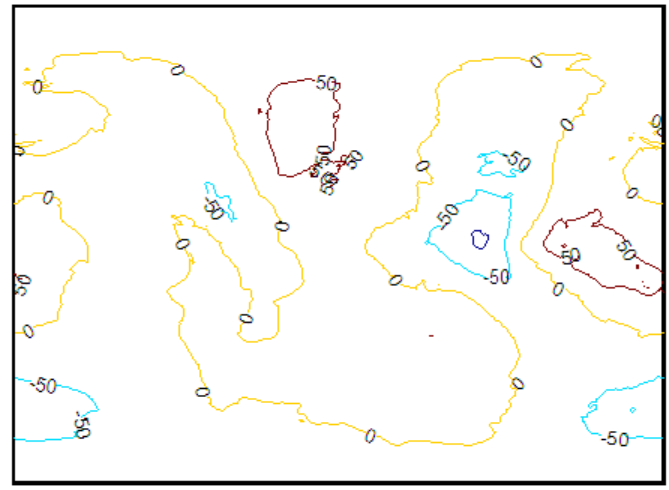
Output Arguments

h

Handle to the `text` and objects

Examples

```
load geoid
axesm miller
framem
tightmap
[c,h] = contourm(geoid,geoidlegend,-100:50:80);
clabelm(c,h)
```



See Also

clegendm | contourm | contour3m | contourfm | clabel

clegendm

Purpose

Add legend labels to map contour display

Syntax

```
clegendm(cs,h)
clegendm(cs,h,loc)
clegendm(...,unitstr)
clegendm(...,strings)
h = clegendm(...)
```

Description

`clegendm(cs,h)` adds a legend specifying the contour line heights to the current map contour plot.

`clegendm(cs,h,loc)` places the legend in the specified location.

`clegendm(...,unitstr)` appends `unitstr` to each entry in the legend.

`clegendm(...,strings)` uses the strings specified in `strings` to label the legend. `strings` must have the same number of entries as the line children of `h`.

`h = clegendm(...)` returns the handle to the `legend` object created.

Input Arguments

cs

Contour matrix output from `contourm`, `contour3m`, or `contourfm`

h

Object handle output from `contourm`, `contour3m`, or `contourfm`

loc

Any of the following integers, with the indicated placement:

Integer	Placement
0	Automatic placement (default)
1	Upper right corner
2	Upper left corner
3	Lower left corner

Integer	Placement
4	Lower right corner
-1	To the right of the plot

unitstr

Character string appended to each entry in the legend

strings

Cell array of strings used to label the legend

Output Arguments

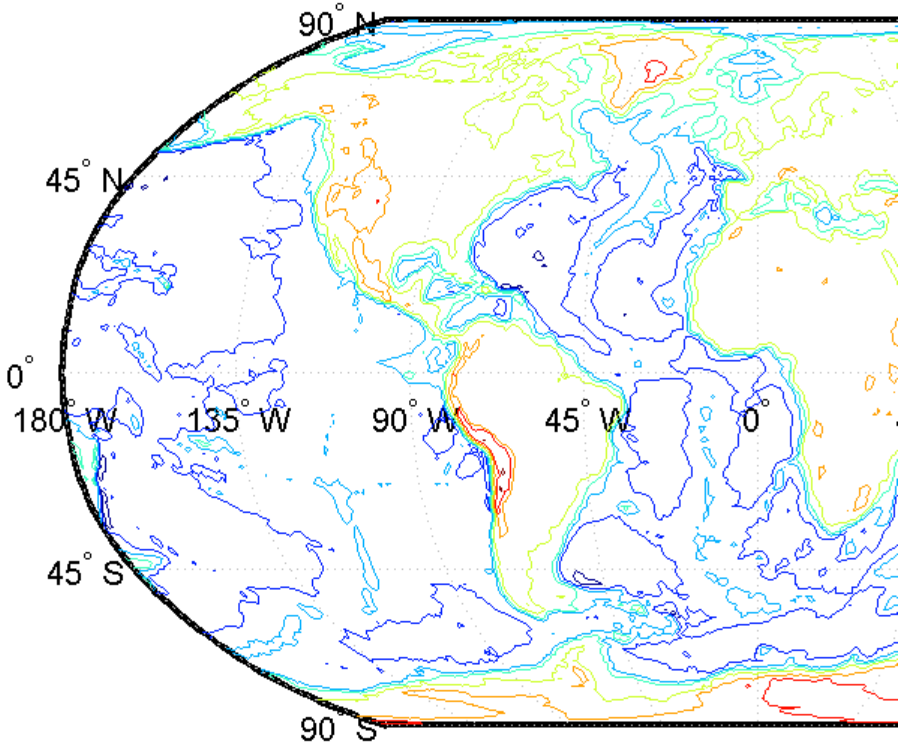
h

Handle to the legend object

Examples

Create a legend in the lower right-hand corner with a unit string indicating that the contour elevations are in meters:

```
load topo
R = georasterref('RasterSize', size(topo), ...
   'Latlim', [-90 90], 'Lonlim', [0 360]);
figure('Color','w'); worldmap('world')
[c,h] = contourm(topo, R, -6000:1500:6000);
clegendm(c,h,4,' m')
```


90° N
45° N
0°
180° W
135° W
90° W
45° W
0°
45° S
90° S

See Also

clabelm | contourm | contour3m | contourfm | contourc | contourcbar

clipdata

Purpose

Clip data at +/-pi in longitude, +/-pi in latitude

Syntax

```
[lat,long,splitpts] = clipdata(lat,long,'object')
```

Description

`[lat,long,splitpts] = clipdata(lat,long,'object')` inserts NaNs at the appropriate locations in a map object so that a displayed map is clipped at the appropriate edges. It assumes that the clipping occurs at +/- pi/2 radians in the latitude (*y*) direction and +/- pi radians in the longitude (*x*) direction.

The input data must be in radians and properly transformed for the particular aspect and origin so that it fits in the specified clipping range.

The output data is in radians, with clips placed at the proper locations. The output variable `splitpts` returns the row and column indices of the clipped elements (columns 1 and 2 respectively). These indices are necessary to restore the original data if the map parameters or projection are ever changed.

Allowable object strings are:

- `surface` for clipping graticules
- `light` for clipping lights
- `line` for clipping lines
- `patch` for clipping patches
- `text` for clipping text object location points
- `point` for clipping point data
- `none` to skip all clipping operations

See Also

`trimdata` | `undoclip` | `undotrim`

Purpose

Clear current map axes

Syntax

```
clma
clma all
clma purge
```

Description

`clma` deletes all displayed map objects from the current map axes but leaves the frame if it is displayed.

`clma all` deletes all displayed map objects, including the frame, but it leaves the map structure intact, thereby retaining the map axes.

`clma purge` clears all displayed map objects and converts the map axes to standard axes. This is equivalent to `cla reset`.

See Also

`cla` | `clmo` | `handlem` | `hidem` | `namem` | `showm` | `tagm`

clmo

Purpose

Clear specified graphics objects from map axes

Syntax

```
clmo
clmo(handle)
clmo(object)
```

Description

`clmo` deletes all displayed graphics objects on the current axes.

`clmo(handle)` deletes those objects specified by their handles.

`clmo(object)` deletes those objects with names identical to the input string. This can be any string recognized by the `handlem` function, including entries in the `Tag` property of each object, or the object `Type` if the `Tag` property is empty.

See Also

`clma` | `handlem` | `hidem` | `namem` | `showm` | `tagm`

Purpose

Close all rings in multipart polygon

Syntax

```
[xdata, ydata] = closePolygonParts(xdata, ydata)
[lat, lon] = closePolygonParts(lat, lon, angleunits)
```

Description

`[xdata, ydata] = closePolygonParts(xdata, ydata)` ensures that each ring in a multipart (`NaN`-separated) polygon is "closed" by repeating the start point at the end of each ring, unless the start and end points are already identical. Coordinate vectors `xdata` and `ydata` must match in size and have identical `NaN` locations.

`[lat, lon] = closePolygonParts(lat, lon, angleunits)` works with latitude-longitude data and accounts for longitude wrapping with a period of `360` if *`angleunits`* is `'degrees'` and `2*pi` if *`angleunits`* is `'radians'`. For a ring to be considered closed, the latitudes of its first and last vertices must match exactly, but their longitudes need only match modulo the appropriate period. Such rings are returned unaltered.

Examples

Closing a polygon in plane coordinates

```
xOpen = [1 0 2 NaN 0.5 0.5 1 1];
yOpen = [0 1 2 NaN 0.8 1 1 0.8];
[xClosed, yClosed] = closePolygonParts(xOpen, yOpen)
xClosed =
  Columns 1 through 7
    1.0000     0    2.0000   1.0000   NaN   0.5000   0.5000
Columns 8 through 10
1.0000    1.0000    0.5000

yClosed =
Columns 1 through 7
0    1.0000    2.0000         0       NaN    0.8000    1.0000
Columns 8 through 10
1.0000    0.8000    0.8000

whos
```

```
  Name         Size            Bytes  Class     Attributes

  xClosed      1x10               80  double
  xOpen        1x8                64  double
  yClosed      1x10               80  double
  yOpen        1x8                64  double
```

Closing a polygon in latitude-longitude coordinates

```
% Construct a two-part polygon based on coast.mat.  The first ring
% is Antarctica.  The longitude of its first vertex is -180 and the
% longitude of its last vertex is 180.  The second ring is a small
% island from which the last vertex, a replica of the first vertex,
% is removed.
c = load('coast.mat');
[latparts, lonparts] = polysplit(c.lat, c.long);
latparts{2}(end) = [];
lonparts{2}(end) = [];
latparts(3:end) = [];
lonparts(3:end) = [];
[lat, lon] = polyjoin(latparts, lonparts);

% Examine how closePolygonParts treats the two rings.  In both
% cases, the first and last vertices differ.  However, Antarctica
% remains unchanged while the small island is closed back up.
[latClosed, lonClosed] = closePolygonParts(lat, lon, 'degrees');
[latpartsClosed, lonpartsClosed] = polysplit(latClosed, lonClosed);
lonpartsClosed{1}(end) - lonpartsClosed{1}(1)  % Result is 360
lonpartsClosed{2}(end) - lonpartsClosed{2}(1)  % Result is 0
```

See Also

isshapemultipart | removeextrananseparators

Purpose

Interactively define RGB color

Note `colorui` will be removed in a future release. Use `uisetcolor` instead.

Syntax

```
c = colorui
c = colorui(InitClr)
c = colorui(InitClr,FigTitle)
```

Description

`c = colorui` will create an interface for the definition of an RGB color triplet. On Windows® platforms, `colorui` will produce the same interface as `uisetcolor`. On other machines, `colorui` produces a platform-independent dialog for specifying the color values.

`c = colorui(InitClr)` will initialize the color value to the RGB triple given in `initclr`.

`c = colorui(InitClr,FigTitle)` will use the string in `FigTitle` as the window label.

The output value `c` is the selected RGB triple if the **Accept** or **OK** button is pushed. If the user presses **Cancel**, then the output value is set to `0`.

See Also

`uisetcolor`

combntns

Purpose

All possible combinations of set of values

Syntax

```
combos = combntns(set,subset)
```

Description

`combos = combntns(set,subset)` returns a matrix whose rows are the various combinations that can be taken of the elements of the vector `set` of length `subset`. Many combinatorial applications can make use of a vector `1:n` for the input set to return generalized, indexed combination subsets.

The `combntns` function provides the combinatorial subsets of a set of numbers. It is similar to the mathematical expression *a choose b*, except that instead of the number of such combinations, the actual combinations are returned. In combinatorial counting, the ordering of the values is not significant.

The numerical value of the mathematical statement *a choose b* is `size(combos,1)`.

Examples

How can the numbers 1 to 5 be taken in sets of three (that is, what is *5 choose 3*)?

```
combos = combntns(1:5,3)

combos =
     1     2     3
     1     2     4
     1     2     5
     1     3     4
     1     3     5
     1     4     5
     2     3     4
     2     3     5
     2     4     5
     3     4     5
size(combos,1)  % "5 choose 3"

ans =
```

```
    10
```

Note that if a value is repeated in the input vector, each occurrence is treated as independent:

```
combos = combntns([2 2 5],2)

combos =
     2     2
     2     5
     2     5
```

Tips

This is a recursive function.

comet3m

Purpose

Project 3-D comet plot on map axes

Syntax

```
comet3m(lat,lon,z)
comet3m(lat,lon,z,p)
```

Description

`comet3m(lat,lon,z)` traces a comet plot through the points specified by the input latitude, longitude, and altitude vectors.

`comet3m(lat,lon,z,p)` specifies a comet body of length `p*length(lat)`. The input `p` is `0.1` by default.

A comet plot is an animated graph in which a circle (the comet *head*) traces the data points on the screen. The comet *body* is a trailing segment that follows the head. The *tail* is a solid line that traces the entire function.

Examples

Create a 3-D comet plot of the coastlines data:

```
load coast
z = (1:length(lat))'/3000;
axesm miller
framem; gridm;
setm(gca,'galtitude',max(z)+.5)
view(3)
comet3m(lat,long,z,0.01)
```

See Also

`comet3` | `cometm`

Purpose

Project 2-D comet plot on map axes

Syntax

```
cometm(lat,lon)
cometm(lat,lon,p)
```

Description

`cometm(lat,lon)` traces a comet plot through the points specified by the input latitude and longitude vectors.

`cometm(lat,lon,p)` specifies a comet body of length `p*length(lat)`. The input `p` is `0.1` by default.

A comet plot is an animated graph in which a circle (the comet *head*) traces the data points on the screen. The comet *body* is a trailing segment that follows the head. The *tail* is a solid line that traces the entire function.

Examples

Create a comet plot of the coastlines data:

```
load coast
axesm miller
framem
cometm(lat,long,0.01)
```

See Also

`comet` | `comet3m`

contour3m

Purpose

Project 3-D contour plot of map data

Description

The `contour3m` function is the same as the `contourm` function except that the lines for each contour level are drawn in their own horizontal plane, at the *z*-coordinate equal to the value of that level.

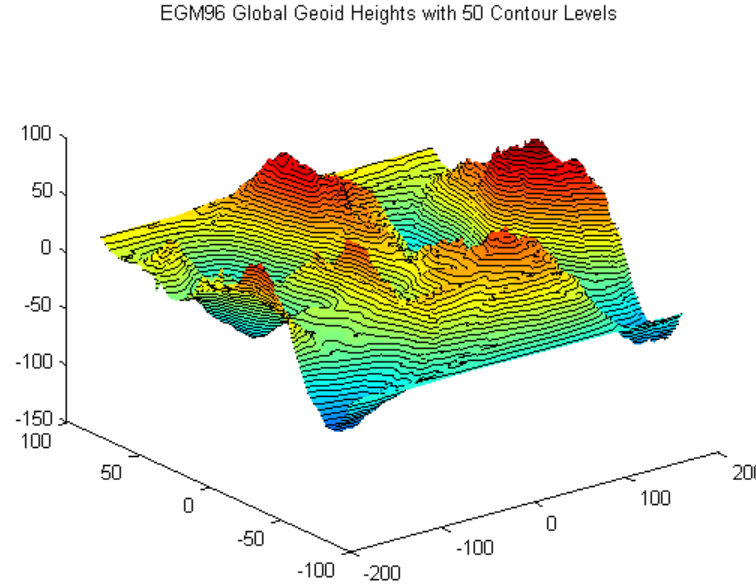
Tips

- If you use `contour3m` with the `globe` map display, the `contour3m` function warns. Be careful to scale the input data relative to the radius of your reference sphere.

Examples

In an ordinary axes, contour the EGM96 geoid heights as a 3-D surface with 50 levels and set the contour line color to black:

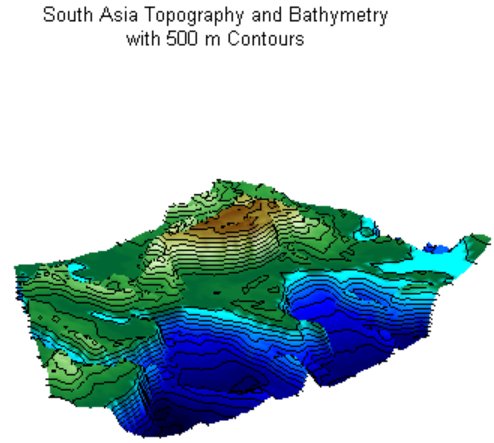
```
figure('Color','white')
load geoid
contour3m(geoid,geoidrefvec,50,'LineColor','black');

% Add the geoid as a surface.
hold on
geoshow(geoid,geoidrefvec,'DisplayType','surface')

% Add a title.
title('EGM96 Global Geoid Heights with 50 Contour Levels');

% View in 3-D
view(3)
```



In a map axes, contour the topography and bathymetry of South Asia and the northern Indian Ocean with a contour interval of 500 meters:

```
load topo
latlim = [ 0  50];
lonlim = [35 115];
[Z, refvec] = maptrims(topo, topolegend, latlim, lonlim);
figure('Color','white')
axesm('lambertstd','MapLatLimit', latlim, 'MapLonLimit', lonlim)
tightmap; axis off
contour3m(Z,refvec,'black','LevelStep',500)

% Add the geoid as a surface and set the colormap.
geoshow(Z,refvec,'DisplayType','surface')
demcmap(Z)
```

```
% Add a title.
title({'South Asia Topography and Bathymetry', ...
   'with 500 m Contours'});

% View in 3-D
set(gca,'DataAspectRatio',[1 1 40000])
view(3)
```



See Also

clabel | clabelm | clegendm | contour | contour3 | contourm | contourfm | geoshow | plot

Purpose

Color bar for filled contour map display

Syntax

```
H = contourcbar(...)
```

Description

`H = contourcbar(...)` creates a color bar associated with a filled contour display created with `contourfm`, `contourm`, `contour3m`, or `geoshow`. It supports the same syntax and usage options as the MATLAB function `colorbar`.

Tips

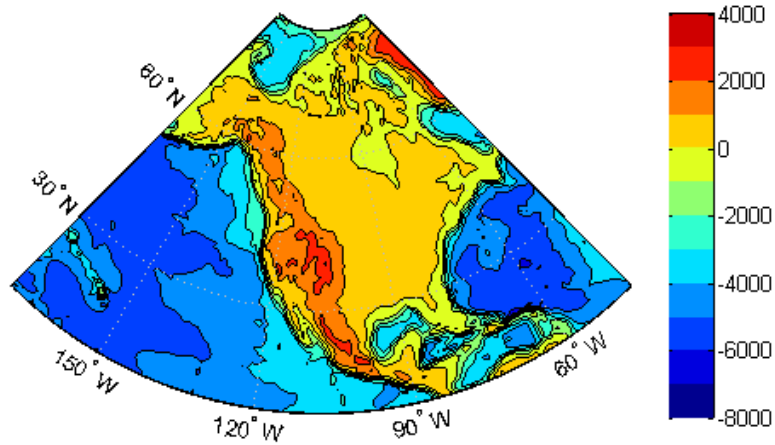
- If a *peer* axes is specified when calling `contourcbar`, it should be a map axes containing an object created using one of the Mapping Toolbox functions listed previously. Otherwise the current axes should contain such an object.
- If a Mapping Toolbox contour object is present, then the color bar is filled with solid blocks of color which bound each other at the contour levels used in the plot. Thus, the contour levels bounding a fill polygon of a given color can be inferred graphically by inspecting the upper and lower limits of the corresponding block in the color bar. In the absence of a Mapping Toolbox contour object an ordinary color bar is created.
- If multiple Mapping Toolbox contour objects are present in the same axes, then the levels used to divide the color bar into blocks will correspond to the first contour object that is found. This situation could occur when a larger data set is broken up into multiple grid tiles, for example, but as long the tiles all use the same contour level list, the color bar will correctly represent them all.

Examples

Add a colorbar to a map showing the topography of North America:

```
figure('Color','white')
worldmap('north america')
load topo
R = georasterref('RasterSize',[180 360], ...
   'Latlim',[-90 90],'Lonlim',[0 360]);
contourfm(topo, R, -7000:1000:3000)
```

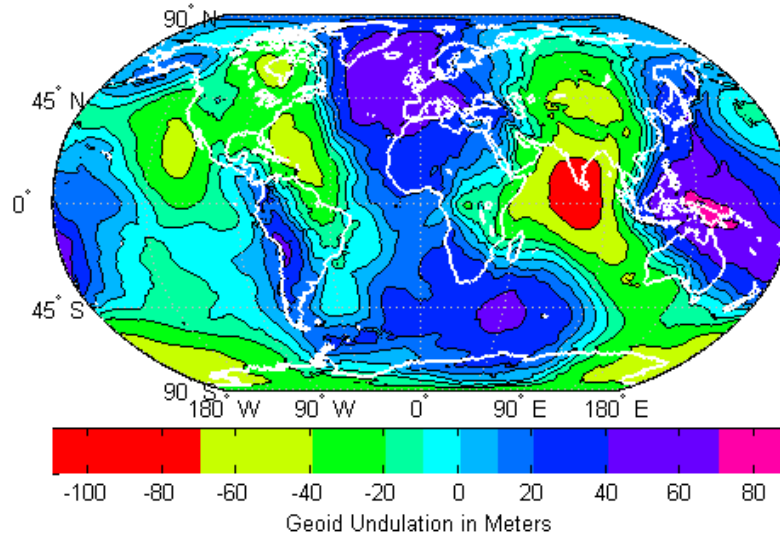
```
caxis([-8000 4000])
contourcbar
```



Add a colorbar to a map showing a geoid with non-uniform levels:

```
figure('Color','white')
ax = worldmap('world');
setm(gca,'MLabelParallel',-90)
setm(gca,'MLabelLocation',90)
load geoid
R = georasterref('RasterSize',[180 360], ...
   'Latlim',[-90 90],'Lonlim', [0 360]);
levels = [-70 -40 -20 -10 0 10 20 40 70];
geoshow(geoid, R, 'DisplayType', 'contour',...
   'LevelList',levels,'Fill','on','LineColor','black')
coast = load('coast.mat');
geoshow(coast.lat, coast.long, 'Color', 'white', 'LineWidth', 1.5)
cb = contourcbar('peer',ax,'Location','southoutside');
```

```
caxis([-110 90])
colormap(hsv)
set(get(cb,'XLabel'),'String','Geoid Undulation in Meters')
```



See Also

clegendm | colorbar | contourfm

contourcmap

Purpose

Contour colormap and colorbar for current axes

Syntax

```
contourcmap(cmapstr)
contourcmap(cmapstr,cdelta)
contourcmap(...,Name,Value)
h = contourcmap(...)
```

Description

`contourcmap(cmapstr)` updates the figure's colormap for the current axes with the colormap specified by `cmapstr`. If the axes contains Mapping Toolbox contour objects, the resultant colormap contains the same number of colors as the original colormap. Otherwise, the resultant colormap contains ten colors.

`contourcmap(cmapstr,cdelta)` updates the figure's colormap with colors varying according to `cdelta`. If the axes contains Mapping Toolbox contour objects, the value of `cdelta` is ignored.

`contourcmap(...,Name,Value)` allows you to add a colorbar and control the colorbar's properties. Parameter names can be abbreviated and are case-insensitive.

`h = contourcmap(...)` returns a handle to the colorbar axes.

Input Arguments

cmapstr

A string that specifies a colormap. Valid entries for `cmapstr` include `'pink'`, `'hsv'`, `'jet'`, or the name of any similar MATLAB colormap function.

cdelta

A scalar or vector. If `cdelta` is a scalar, it represents a step size, and colors are generated at multiples of `cdelta`. If `cdelta` is a vector of evenly spaced values, colors are generated at those values; otherwise an error is issued.

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding

value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

Colorbar

String with values `'on'` or `'off'` specifying whether a colorbar is present, `'on'`, or absent from the axes, `'off'`.

Default: `'off'`

Location

String specifying the location of the colorbar. Permissible values are `'vertical'`, `'horizontal'`, or `'none'`.

Default: `'vertical'`

ColorAlignment

String specifying the alignment of the labels in the colorbar. Permissible values are `'center'`, where the labels are centered on the color bands, or `'ends'`, where the labels are centered on the color breaks. If the axes contains Mapping Toolbox contour objects, the `ColorAlignment` will be set automatically to `'center'` for contour lines and `'ends'` for filled contours, and cannot be modified.

SourceObject

Handle of the graphics object which is used to determine the color limits for the colormap. The `SourceObject` value is the handle of a currently displayed object.

Default: `gca`

TitleString

String specifying the title of the colorbar axes.

XLabelString

String specifying the `X` label of the colorbar axes.

YLabelString

String specifying the `Y` label of the colorbar axes.

ZLabelString

String specifying the `Z` label of the colorbar axes. In addition, properties and values that can be applied to the title and labels of the colorbar axes are valid.

Output Arguments

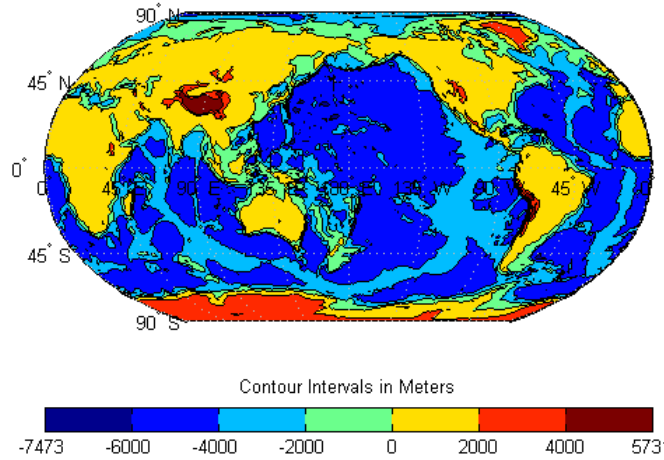
h

A handle to the colorbar axes.

Examples

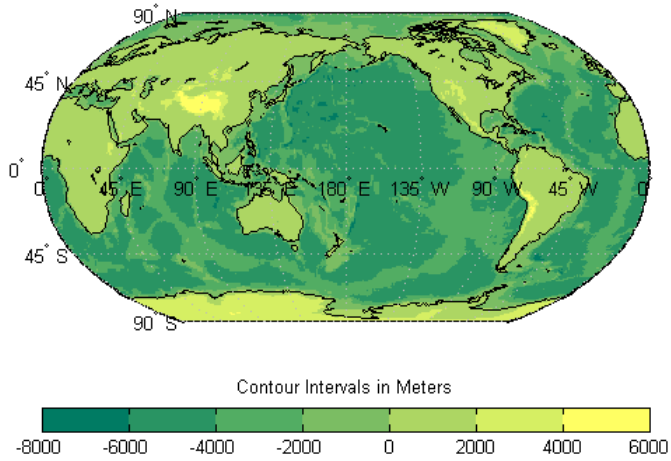
Display a world map with a colormap representing contour intervals in meters:

```
load topo
R = georasterref('RasterSize', size(topo), ...
   'Latlim', [-90 90], 'Lonlim', [0 360]);
figure('Color','white')
worldmap(topo, R)
contourfm(topo, R);
contourcmap('jet', 'Colorbar', 'on', ...
   'Location', 'horizontal', ...
   'TitleString', 'Contour Intervals in Meters');
```



Display a world map with a colormap in which colors vary at a step size of 2000:

```
load topo
load coast
R = georasterref('RasterSize', size(topo), ...
   'Latlim', [-90 90], 'Lonlim', [0 360]);
figure('Color','white')
worldmap(topo, R)
geoshow(topo, R, 'DisplayType', 'texturemap');
contourcmap('summer', 2000, 'Colorbar', 'on', ...
   'Location', 'horizontal', ...
   'TitleString', 'Contour Intervals in Meters');
geoshow(lat, long, 'Color', 'black')
```



See Also

`clabelm` | `clegendm` | `colormap` | `contour3m` | `contourcbar` | `contourfm` | `contourm`

Purpose

Project filled 2-D contour plot of map data

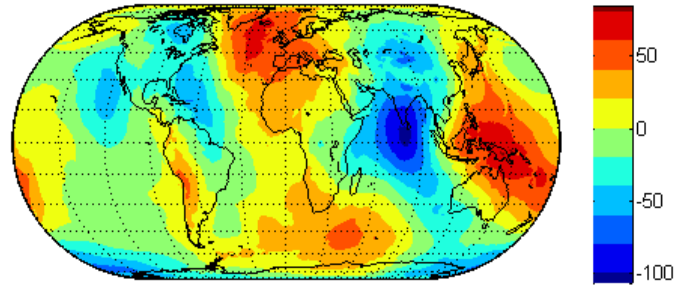
Description

The `contourfm` function is the same as the `contourm` function except that the areas between contours are filled with colors. For each contour interval, `contourfm` selects a distinct color from the figure's colormap. You can obtain the same result by setting `'Fill','on'` and `'LineColor','black'` when calling `contourm`.

Examples

Plot the Earth's geoid with filled contours. The data is in meters.

```
figure
axesm eckert4; framem; gridm; axis off; tightmap

load geoid
contourfm(geoid, geoidrefvec, -120:20:100, 'LineStyle', 'none');

coast = load('coast');
geoshow(coast.lat, coast.long, 'Color', 'black')

contourcbar
```



See Also

`contourcbar` | `contourm` | `contour3m` | `clabelm` | `meshm` | `surfm`

contourm

Purpose

Project 2-D contour plot of map data

Syntax

```
contourm(Z,R)
contourm(lat,lon,Z)
contourm(Z,R,n) or contourm(lat,lon,Z,n)
contourm(Z,R,V) or contourm(lat,lon,Z,V)
contourm(...,LineSpec)
contourm(...,Name,Value,...)
C = contourm(...)
[C,h] = contourm(...)
```

Description

`contourm(Z,R)` creates a contour plot of the regular data grid `Z` with referencing vector or matrix `R`.

`contourm(lat,lon,Z)` displays a contour plot of the geolocated, M-by-N data grid, `Z`.

`contourm(Z,R,n) or contourm(lat,lon,Z,n)` draws `n` contour levels.

`contourm(Z,R,V) or contourm(lat,lon,Z,V)` draws contours at the levels specified by the input vector `V`. Use `V = [v v]` to compute a single contour at level `v`.

`contourm(...,LineSpec)` uses any valid `LineSpec` string to draw the contour lines.

`contourm(...,Name,Value,...)` allows you to set optional parameters. Parameter names can be abbreviated, and case does not matter. In addition, any of the following `hggroup properties` may be specified: HandleVisibility, Parent, Tag, UserData, and Visible.

`C = contourm(...)` returns contour matrix `C`.

`[C,h] = contourm(...)` returns the contour matrix and the handle to the `hggroup` containing the contour lines.

Tips

You have three ways to control the number of contour levels that display in your map:

1. Set the number of contour levels by specifying the scalar `n` in the syntax `contourm(Z,R,n)` or `contourm(lat,lon,Z,n)`.
2. Use the vector `V` to specify the levels at which contours are drawn with the syntax `contourm(Z,R,V)` or `contourm(lat,lon,Z,V)`.
3. Choose regular intervals at which the contours are drawn by setting the `LevelStep` parameter.

If you do not use any of the above methods to set your contour levels, the `contourm` function will display around five contour levels.

Input Arguments

Z

Regular or geolocated data grid.

If the grid contains regions with missing data, set the corresponding elements of `Z` to NaN. Contour lines terminate when entering such areas. Similarly, if you use `'Fill','on'` or call `contourfm`, such null-data areas will not be filled. If the syntax `contourm(lat,lon,Z,...)` is used, however, `lat` and `lon` must have finite, non-NaN values everywhere. In this case, set `Z` to NaN in null data areas, but make sure the corresponding elements of `lat` and `lon` have finite values that specify actual locations on the Earth.

R

`spatialref.GeoRasterReference` object, referencing vector, or referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. For more information about referencing vectors and matrices, see the section "Understanding Raster Geodata" in the User's Guide. If the current axis is a map axis, the coordinates of `Z` will be projected using the projection structure from the axis. The contours are drawn at their corresponding `Z` level.

lat,lon

Geolocation arrays having the same size as `Z`, or vectors with length (`lat`) matching the number of rows in `Z` and length (`lon`) matching the number of columns in `Z`.

n

Scalar specifying the number of contour levels.

V

Vector specifying contour levels.

LineSpec

Line specification string. See the MATLAB function reference page for `LineSpec` for more information.

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

Fill

```
off | on
```

Color areas between contour lines. By default `contourm` draws a line (which may have multiple parts) for each contour level. If you set `Fill` to `on`, `contourm` colors the polygonal regions between the lines, selecting a distinct color for each contour interval from the colormap of the figure in which the contours are drawn. Setting `Fill` to `on` is almost the same as calling `contourfm`; the only difference is that `contourfm` also sets `LineColor` to black by default.

Default: `off`

LabelSpacing

`scalar`

Spacing between labels on each contour line. When you display contour line labels either by calling `clabelm` or by specifying `'ShowText','on'`, the labels by default are spaced 144 points (2 inches) apart on each line. You can specify the spacing by setting `LabelSpacing` to a value in points. If the length of an individual contour line is less than the specified value, only one contour label is displayed on that line.

LevelList

`vector`

Values at which contour lines are drawn. This property uses a row vector of increasing values to specify the levels at which contour lines are drawn.

LevelStep

`scalar`

Spacing of contour lines. When `LevelStep`, which must be a positive real number, is specified, the `contourm` function draws contour lines at regular intervals determined by the value of `LevelStep`, unless the optional third argument, `n` (number of contour levels) or `V` (vector specifying contour levels) is provided. If `n` or `V` is used in combination with the `LevelStep` parameter, then the `LevelStep` parameter is

ignored. If `n`, `v`, and the `LevelStep` parameter are all omitted, `contourm` selects a uniform step automatically.

LineColor

`flat | ColorSpec | none`

Contour line colors. To specify a single color to be used for all the contour lines, you can set `ColorSpec` to a three-element RGB vector or one of the MATLAB predefined names. See the MATLAB `ColorSpec` reference page for more information on specifying color. If you omit `LineColor` or set it to `flat`, `contourm` selects a distinct color for lines at each contour level from the colormap of the figure in which the contours are drawn. If you set `LineColor` to `none`, the contour lines will not be visible.

Default: `flat`

LineStyle

`- | -- | : | -. | none`

Line style for contour lines. Options for `LineStyle` include solid (specified by -), dashed (--), dotted (:), dash-dot (-.), and none. The specifier strings work the same as for line objects in MATLAB graphics.

Default: `-`

LineWidth

`scalar`

Width of the contour lines in points (1 point = 1/72 inch).

Default: `0.5`

ShowText

`on | off`

Display labels on contour lines. If you set `ShowText` to `on`, `contourm` displays text labels on each contour line indicating the value of the

corresponding contour level. Another way to add labels to your contour lines is to call `clabelm` after calling `contourm`.

Default: `off`

Output Arguments

C

Standard contour matrix with the first row representing longitude data and the second row representing latitude data.

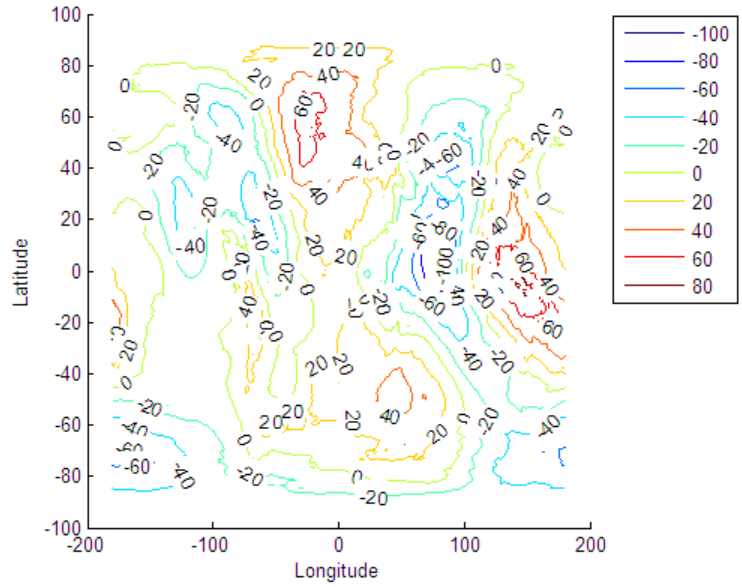
h

Handle to the `hggroup` containing the contour lines.

Examples

Contour EGM96 geoid heights, label them, and add a legend:

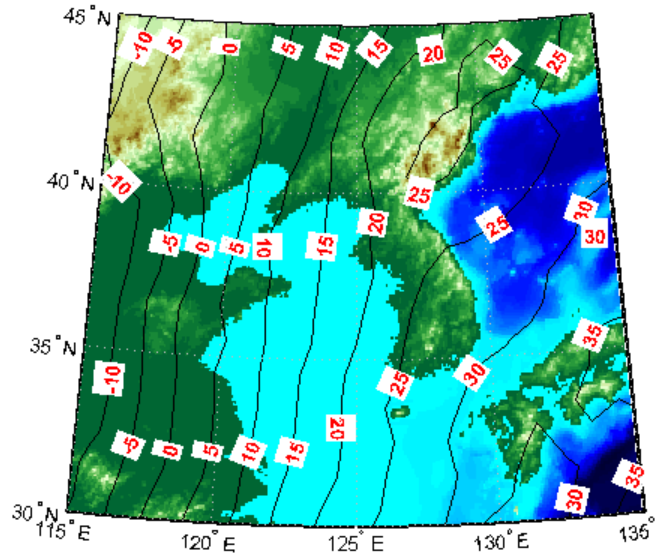
```
load geoid
figure
[c,h] = contourm(geoid,geoidrefvec,'LevelStep',20,'ShowText','on');
xlabel('Longitude')
ylabel('Latitude')
clegendm(c,h,-1)
```



Contour geoid heights for an area including Korea with a backdrop of terrain elevations and bathymetry:

```
% Load the data.
load korea
load geoid

% Create a map axes that includes Korea.
figure
worldmap(map, refvec)

% Display the digital elevation data and apply a colormap.
geoshow(map, refvec, 'DisplayType', 'texturemap');
demcmap(map)

% Contour the geoid values from -100 to 100 in increments of 5.
```

```
[c,h] = contourm(geoid, geoidlegend, -100:5:100, 'k');

% Add red labels with white backgrounds to the contours.
ht = clabelm(c,h);
set(ht,'Color','r','BackgroundColor','white','FontWeight','bold')
```



See Also

clabelm | clegendm | contour | contourc | contour3 | contour3m | contourfm | geoshow | plot

Purpose

Convert between geodetic and auxiliary latitudes

Syntax

```
latout = convertlat(ellipsoid,latin,from,to,units)
```

Description

`latout = convertlat(ellipsoid,latin,from,to,units)` converts latitude values in `latin` from type `FROM` to type `TO`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`.

`latin` is an array of input latitude values. `from` and `to` are each one of the latitude type strings listed below (or unambiguous abbreviations). `latin` has the angle units specified by `units`: either `'degrees'`, `'radians'`, or unambiguous abbreviations. The output array, `latout`, has the same size and units as `latin`.

Latitude Type	Description
`geodetic`	The geodetic latitude is the angle that a line perpendicular to the surface of the ellipsoid at the given point makes with the equatorial plane.
`authalic`	The authalic latitude maps an ellipsoid to a sphere while preserving surface area. Authalic latitudes are used in place of the geodetic latitudes when projecting the ellipsoid using an equal area projection.
`conformal`	The conformal latitude maps an ellipsoid conformally onto a sphere. Conformal latitudes are used in place of the geodetic latitudes when projecting the ellipsoid with a conformal projection.
`geocentric`	The geocentric latitude is the angle that a line connecting a point on the surface of the ellipsoid to its center makes with the equatorial plane.
`isometric`	The isometric latitude is a nonlinear function of the geodetic latitude.

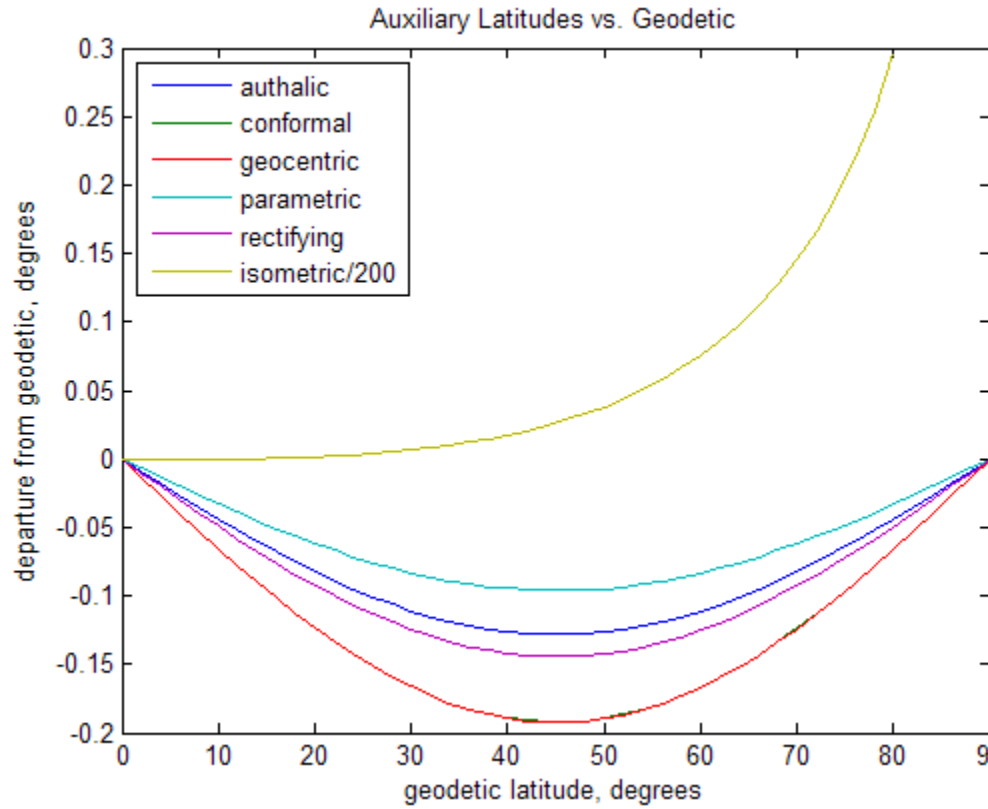
Latitude Type	Description
`parametric`	The parametric latitude of a point on the ellipsoid is the latitude on a sphere of radius a, where a is the semimajor axis of the ellipsoid, for which the parallel has the same radius as the parallel of geodetic latitude.
`rectifying`	The rectifying latitude is used to map an ellipsoid to a sphere in such a way that distance is preserved along meridians.

To properly project rectified latitudes, the radius must also be scaled to ensure the equal meridional distance property. This is accomplished by `rsphere`.

Examples

```
% Plot the difference between the auxiliary latitudes
% and geocentric latitude, from equator to pole,
% using the GRS 80 ellipsoid. Avoid the polar region with
% the isometric latitude, and scale down the difference
% by a factor of 200.
grs80 = referenceEllipsoid('grs80');
geodetic = 0:2:90;
authalic = ...
convertlat(grs80,geodetic,'geodetic','authalic', 'deg');
conformal = ...
convertlat(grs80,geodetic,'geodetic','conformal', 'deg');
geocentric = ...
convertlat(grs80,geodetic,'geodetic','geocentric','deg');
parametric = ...
convertlat(grs80,geodetic,'geodetic','parametric','deg');
rectifying = ...
convertlat(grs80,geodetic,'geodetic','rectifying','deg');
isometric = ...
convertlat(grs80,geodetic(1:end-5), ...
'geodetic','isometric','deg');
plot(geodetic, (authalic - geodetic),...
geodetic, (conformal - geodetic),...
```

```
geodetic, (geocentric - geodetic),...
geodetic, (parametric - geodetic),...
geodetic, (rectifying - geodetic),...
geodetic(1:end-5), (isometric - geodetic(1:end-5))/200);
title('Auxiliary Latitudes vs. Geodetic')
xlabel('geodetic latitude, degrees')
ylabel('departure from geodetic, degrees');
legend('authalic','conformal','geocentric', ...
'parametric','rectifying', 'isometric/200',...
'Location','NorthWest');
```



See Also

`referenceEllipsoid` | `referenceSphere` | `oblateSpheroid` | `rsphere`

crossfix

Purpose

Cross-fix positions from bearings and ranges

Syntax

```
[newlat,newlon] = crossfix(lat,long,az)
[newlat,newlon] = crossfix(lat,long,az_range,case)
[newlat,newlon] = crossfix(lat,long,az_range,case,drlat,
   drlong)
[newlat,newlon] = crossfix(lat,long,az,units)
[newlat,newlon] = crossfix(lat,long,az_range,case,units)
[newlat,newlon] = crossfix(lat,long,az_range,drlat,drlong,
   units)
[newlat,newlon] =  crossfix(lat,long,az_range,case,drlat,
   drlong,units)
mat = crossfix(...)
```

Description

`[newlat,newlon] = crossfix(lat,long,az)` returns the intersection points of all pairs of great circles passing through the points given by the column vectors `lat` and `long` that have azimuths `az` at those points. The outputs are two-column matrices `newlat` and `newlon` in which each row represents the two intersections of a possible pairing of the input great circles. If there are *n* input objects, there will be *n choose 2* pairings.

`[newlat,newlon] = crossfix(lat,long,az_range,case)` allows the input `az_range` to specify either azimuths or ranges. Where the vector `case` equals 1, the corresponding element of `az_range` is an azimuth; where `case` is 0, `az_range` is a range. The default value of `case` is a vector of ones (azimuths).

`[newlat,newlon] = crossfix(lat,long,az_range,case,drlat,drlong)` resolves the ambiguities when there is more than one intersection between two objects. The scalar-valued `drlat` and `drlong` provide the location of an estimated (dead reckoned) position. The outputs `newlat` and `newlong` are column vectors in this case, returning only the intersection closest to the estimated point. When this option is employed, if any pair of objects fails to intersect, no output is returned and the warning `No Fix` is displayed.

`[newlat,newlon] = crossfix(lat,long,az,`*`units`*`)`, `[newlat,newlon] = crossfix(lat,long,az_range,case,`*`units`*`)`, `[newlat,newlon] = crossfix(lat,long,az_range,drlat,drlong,`*`units`*`)`, and `[newlat,newlon] = crossfix(lat,long,az_range,case,drlat,drlong,`*`units`*`)` allow the specification of the angle units to be used for all angles and ranges, where *`units`* is any valid angle units string. The default value of *`units`* is `'degrees'`.

`mat = crossfix(...)` returns the output in a two- or four-column matrix `mat`.

This function calculates the points of intersection between a set of objects taken in pairs. Given great circle azimuths and/or ranges from input points, the locations of the possible intersections are returned. This is different from the navigational function `navfix` in that `crossfix` uses great circle measurement, while `navfix` uses rhumb line azimuths and nautical mile distances.

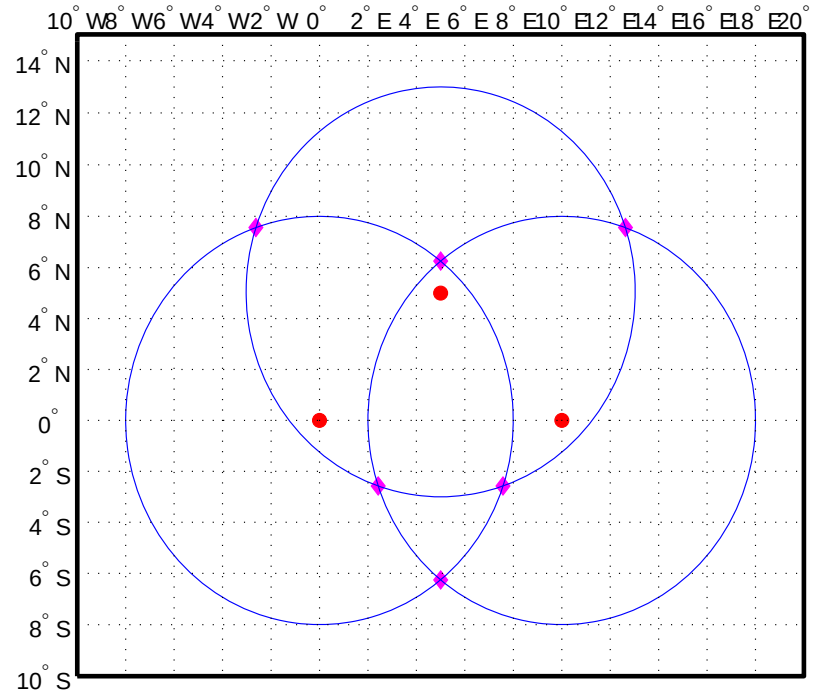
Examples

Where do the small circles defined as all points 8º in distance from the points (0º,0º), (5ºN,5ºE), and (0º,10ºE)" intersect?

```
figure('color','w');
ha = axesm('mapproj','mercator', ...
    'maplatlim',[-10 15],'maplonlim',[-10 20],...
    'MLineLocation',2,'PLineLocation',2);
axis off, gridm on, framem on;
mlabel on, plabel on;
latpts = [0;5;0];           % Define latitudes of three arbitrary points
lonpts = [0;5;10];          % Define longitudes of three arbitrary points
radii = [8;8;8];            % Define three radii, all 8 degrees

% Obtain intersections of imagined small circles around these points
[newlat,newlon] = crossfix(latpts,lonpts,radii,[0;0;0])

% Draw red circle markers at the given points
geoshow(latpts,lonpts,'DisplayType','point',...
```

```
    'markeredgecolor','r','markerfacecolor','r','marker','o')

% Draw magenta diamond markers at intersection points just found
geoshow(reshape(newlat,6,1),reshape(newlon,6,1),'DisplayType','point',...
    'markeredgecolor','m','markerfacecolor','m','marker','d')

% Generate a small circle 8 deg radius for each original point
[latc1,lonc1] = scircle1(latpts(1),lonpts(1),radii(1));
[latc2,lonc2] = scircle1(latpts(2),lonpts(2),radii(2));
[latc3,lonc3] = scircle1(latpts(3),lonpts(3),radii(3));

% Plot the small circles to show the intersections are as determined
geoshow(latc1,lonc1,'DisplayType','line',...
    'color','b','linestyle','-')
geoshow(latc2,lonc2,'DisplayType','line',...
    'color','b','linestyle','-')
geoshow(latc3,lonc3,'DisplayType','line',...
    'color','b','linestyle','-')
```

The diagram shows why there are six intersections:



If a dead reckoning position is provided, say (0º,5ºE), then one from each pair is returned (the closest one):

```
[newlat,newlong] = crossfix([0 5 0]',[0 5 10]',...
                            [8 8 8]',[0 0 0]',0,5)

newlat =
   -2.5744
    6.2529
   -2.5744

newlong =
    7.5770
    5.0000
```

```
    2.4230
```

See Also

gcxgc | gcxsc | scxsc | rhxrh | polyxpoly | navfix

Purpose

Control vertical exaggeration in map display

Syntax

```
daspectm(zunits)
daspectm(zunits,vfac)
daspectm(zunits,vfac,lat,long)
daspectm(zunits,vfac,lat,long,az)
daspectm(zunits,vfac,lat,long,az,radius)
```

Description

`daspectm(zunits)` sets the figure `'DataAspectRatio'` property so that the *z*-axis is in proportion to the *x*-and *y*-projected coordinates. This permits elevation data to be displayed without vertical distortion. The string *`zunits`* specifies the units of the elevation data, and can be any string recognized by `unitsratio`.

`daspectm(zunits,vfac)` sets the `'DataAspectRatio'` property so that the *z*-axis is vertically exaggerated by the factor `vfac`. If omitted, the default is no vertical exaggeration.

`daspectm(zunits,vfac,lat,long)` sets the aspect ratio based on the local map scale at the specified geographic location. If omitted, the default is the center of the map limits.

`daspectm(zunits,vfac,lat,long,az)` also specifies the direction along which the scale is computed. If omitted, 90 degrees (west) is assumed.

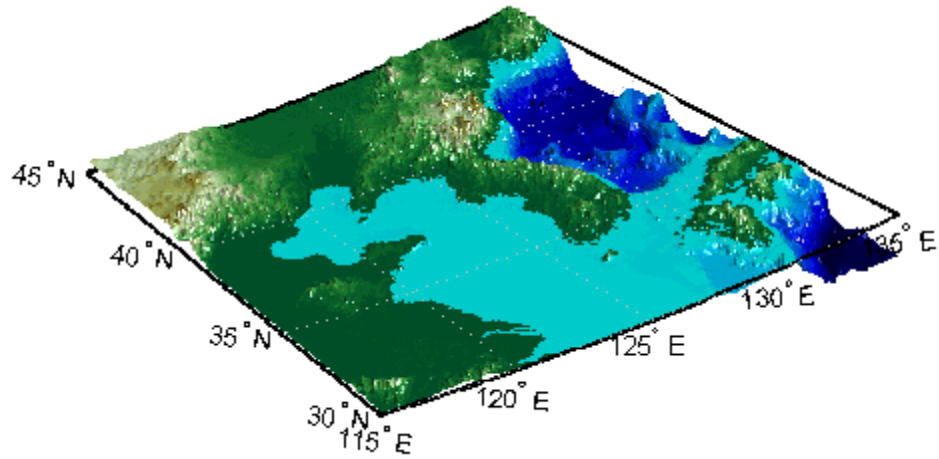
`daspectm(zunits,vfac,lat,long,az,radius)` uses the last input to determine the radius of the sphere. `radius` can be one of the strings supported by `km2deg`, or it can be the (numerical) radius of the desired sphere in `zunits`. If omitted, the default radius of the Earth is used.

Examples

Show the elevation map of the Korean peninsula with a vertical exaggeration factor of 30:

```
load korea
[latlim,lonlim] = limitm(map,refvec);
worldmap(latlim,lonlim)
meshm(map,refvec,size(map),map)
demcmap(map)
```

```
view(3)
daspectm('m',30)
tightmap
camlight
```



Limitations

The relationship between the vertical and horizontal coordinates holds only as long as the `geoid` or scale factor properties of the map axes remain unchanged. If you change the scaling between geographic coordinates and projected axes coordinates, execute `daspectm` again.

See Also

`daspect` | `paperscale`

Purpose

Read selected DCW worldwide basemap data

Syntax

```
struct = dcwdata(library,latlim,lonlim,theme,topolevel)
struct = dcwdata(devicename,library,...)
[struct1, struct2,...] =
dcwdata(...,{topolevel1,topolevel2,
   ...})
```

Description

`struct = dcwdata(library,latlim,lonlim,theme,topolevel)` reads data for the specified theme and topology level directly from the DCW CD-ROM. There are four CDs, one for each of the libraries: `'NOAMER'` (North America), `'SASAUS'` (Southern Asia and Australia), `'EURNASIA'` (Europe and Northern Asia), and `'SOAMAFR'` (South America and Africa). The desired theme is specified by a two-letter code string. A list of valid codes is displayed when an invalid code, such as `'?'`, is entered. The region of interest can be given as a point latitude and longitude or as a region with two-element vectors of latitude and longitude limits. The units of latitude and longitude are degrees. The data covering the requested region is returned, but will include data extending to the edges of the 5-by-5 degree tiles. The result is returned as a Version 1 Mapping Toolbox display structure.

`struct = dcwdata(devicename,library,...)` specifies the logical device name of the CD-ROM for computers that do not automatically name the mounted disk.

`[struct1, struct2,...] = dcwdata(...,{topolevel1,topolevel2,...})` reads several topology levels. The levels must be specified as a cell array with the entries `'patch'`, `'line'`, `'point'`, or `'text'`. Entering `{'all'}` for the topology level argument is equivalent to `{'patch', 'line', 'point', 'text'}`. Upon output, the data structures are returned in the output arguments by topology level in the same order as they were requested.

Background

The Digital Chart of the World (DCW) is a detailed and comprehensive source of publicly available global vector data. It was digitized from the Operational Navigation Charts (scale 1:1,000,000) and Jet Navigation

Charts (1:2,000,000), compiled by the U.S. Defense Mapping Agency (DMA) along with mapping agencies in Australia, Canada, and the United Kingdom. The digitized data was published on four CD-ROMS by the DMA and is distributed by the U.S. Geological Survey (USGS).

The DCW is out of print and has been succeeded by the Vector Map Level 0 (VMAP0).

The DCW organizes data into 17 different themes, such as political/oceans (PO), drainage (DN), roads (RD), or populated places (PP). The data is further tiled into 5-by-5 degree tiles and separated by topology level (patches, lines, points, and text).

Tips

Latitudes and longitudes use WGS84 as a horizontal datum. Elevations are in feet above mean sea level. The data set does not contain bathymetric data.

Some DCW themes do not contain all topology levels. In those cases, empty matrices are returned.

The data is tagged with strings describing the objects. Some data is provided with alternate tags in `tag2` and `tag3` fields. These alternate tags contain information that supplements the standard tag, such as the names of political entities or values of elevation. The `tag2` field generally has the actual values or codes associated with the data. If the information in the `tag2` field expands to more verbose descriptions, these are provided in the `tag3` field.

Point data for which there are descriptions of both the type and the individual names of objects is returned twice within the structure. The first set is a collection of points of the same type with appropriate tag. The second is a set of individual points with the tag `'Individual Points'` and the name of the object in the `tag2` field.

Patches are broken at the tile boundaries. Setting the `EdgeColor` to `'none'` and plotting the lines gives the map a normal appearance.

The DCW was published in 1992 based on data compiled some years earlier. The political boundaries do not reflect recent changes such as the dissolution of the Soviet Union, Czechoslovakia, and Yugoslavia.

In some cases, the boundaries of the successor nations are present as lower level political units. A new version, called VMAP0.

For information about the format of display structures, see "Version 1 Display Structures" on page 3-177 in the reference page for `displaym`.

Examples

On a Macintosh computer,

```
s = dcwdata('NOAMER',41,-69,'?','patch');

??? Error using ==> dcwdata
Theme not present in library NOAMER
Valid two-letter theme identifiers are:
PO: Political/Oceans
PP: Populated Places
LC: Land Cover
VG: Vegetation
RD: Roads
RR: Railroads
UT: Utilities
AE: Aeronautical
DQ: Data Quality
DN: Drainage
DS: Supplemental Drainage
HY: Hypsography
HS: Supplemental Hypsography
CL: Cultural Landmarks
OF: Ocean Features
PH: Physiography
TS: Transportation Structure
POpatch = dcwdata('NOAMER',[41 44],[-72 -69],'PO','patch')
POpatch =
1x234 struct array with fields:
    type
    otherproperty
    tag
    altitude
```

```
    lat
    long
    tag2
    tag3
```

On an MS-DOS based operating system with the CD-ROM as the `'d:'` drive,

```
[RDtext,RDline] = dcwdata('d:','SASAUS',[-48 -34],[164 180],...
     'RD',{'text','line'});
```

On a UNIX® operating system with the CD-ROM mounted as `'\cdrom'`,

```
[POpatch,POline,POpoint,POtext] = dcwdata('\cdrom',...
     'EURNASIA',-48 ,164,'PO',{'all'});
```

References

The format and the history of the DCW are described in reference [1] of the "Bibliography" at the end of this chapter.

See Also

dcwgaz | dcwread | dcwrhead | displaym | extractm | mlayers | updategeostruct | vmap0data

Purpose

Search DCW worldwide basemap gazette file

Syntax

```
dcwgaz(library,object)
dcwgaz(devicename,library,object)
mtextstruc = dcwgaz(...)
[mtextstruc,mpointstruc] = dcwgaz(...)
```

Description

`dcwgaz(library,object)` searches the DCW library for items beginning with the *`object`* string. There are four CDs, one for each of the libraries: `'NOAMER'` (North America), `'SASAUS'` (Southern Asia and Australia), `'EURNASIA'` (Europe and Northern Asia), and `'SOAMAFR'` (South America and Africa). Items that exactly match or begin with the *`object`* string are displayed on screen.

`dcwgaz(devicename,library,object)` specifies the logical device name of the CD-ROM for computers that do not automatically name the mounted disk.

`mtextstruc = dcwgaz(...)` displays the matched items on screen and returns a Mapping Toolbox display structure with the matches as text entries.

`[mtextstruc,mpointstruc] = dcwgaz(...)` returns the matches in structures formatted both as text and as points.

Background

In addition to the geographic data, the Digital Chart of the World (DCW) also includes an extensive gazette feature. The gazette is a collection of the names of geographic items mentioned in the various themes of a DCW disk. One DCW disk can contain about 10,000 to 15,000 names. This function allows you to search the gazette for names beginning with a particular string.

Tips

The search is not case sensitive. Items that match are those that begin with the *`object`* string. Spaces are significant.

Examples

On a Macintosh computer,

```
s = dcwgaz('EURNASIA','apatin')
```

```
APATIN
s =
             type: 'text'
    otherproperty: {1x2 cell}
              tag: 'Built up area'
           string: 'APATIN'
         altitude: []
              lat: 45.6660
             long: 18.9830
```

On a UNIX operating system with the CD-ROM mounted as `'\cdrom'`,

```
[mtextstruc,mpointstruc] = ...
    dcwgaz('\cdrom','SOAMAFR', 'cape good')

Cape Goodenough
Cape Goodenough
Cape Goodenough
mtextstruc =
1x3 struct array with fields:
    type
    otherproperty
    tag
    string
    altitude
    lat
    long
mpointstruc =
1x3 struct array with fields:
    type
    otherproperty
    tag
    string
    altitude
    lat
    long
```

See Also

dcwdata | dcwread | dcwrhead | mlayers | updategeostruct

dcwread

Purpose

Read DCW worldwide basemap file

Syntax

```
dcwread(filepath,filename)
dcwread(filepath,filename,recordIDs)
dcwread(filepath,filename,recordIDs,field,varlen)
struc = dcwread(...)
[struc,field] = dcwread(...)
[struc,field,varlen] = dcwread(...)
[struc,field,varlen,description] = dcwread(...)
[struc,field,varlen,description,
   narrativefield] = dcwread(...)
```

Description

`dcwread` reads a DCW file. The user selects the file interactively.

`dcwread(filepath,filename)` reads the specified file. The combination `[filepath filename]` must form a valid complete filename.

`dcwread(filepath,filename,recordIDs)` reads selected records or fields from the file. If `recordIDs` is a scalar or a vector of integers, the function returns the selected records. If `recordIDs` is a cell array of integers, all records of the associated fields are returned.

`dcwread(filepath,filename,recordIDs,field,varlen)` uses previously read field and variable-length record information to skip parsing the file header (see below).

`struc = dcwread(...)` returns the file contents in a structure.

`[struc,field] = dcwread(...)` returns the file contents and a structure describing the format of the file.

`[struc,field,varlen] = dcwread(...)` also returns a vector describing the fields that have variable-length records.

`[struc,field,varlen,description] = dcwread(...)` also returns a string describing the contents of the file.

`[struc,field,varlen,description,narrativefield] = dcwread(...)` also returns the name of the narrative file for the current file.

Background

The Digital Chart of the World (DCW) uses binary files in a variety of formats. This function determines the format of the file and returns the contents in a structure. The field names of this structure are the same as the field names in the DCW file.

Tips

This function reads all DCW files except index files (files with names ending in `'X'`), thematic index files (files with names ending in `'TI'`), and spatial index files (files with names ending in `'SI'`).

File separators are platform dependent. The *`filepath`* input must use appropriate file separators, which you can determine using the MATLAB `filesep` function.

Examples

The following examples use the Macintosh directory system and file separators for the pathname:

```
s = dcwread('NOAMER:DCW:NOAMER:','GRT')
s =
                    ID: 1
             DATA_TYPE: 'GEO'
                 UNITS: '014'
             ELLIPSOID: 'WGS 84'
    ELLIPSOID_DETAIL: 'A=6378137,B=6356752 Meters'
      VERT_DATUM_REF: 'MEAN SEA LEVEL'
     VERT_DATUM_CODE: '015'
         SOUND_DATUM: 'MEAN SEA LEVEL'
    SOUND_DATUM_CODE: '015'
      GEO_DATUM_NAME: 'WGS 84'
      GEO_DATUM_CODE: 'WGE'
     PROJECTION_NAME: 'DECIMAL DEGREES'

s = dcwread('NOAMER:DCW:NOAMER:AE:','INT.VDT')
s =
5x1 struct array with fields:
    ID
    TABLE
    ATTRIBUTE
```

```
    VALUE
    DESCRIPTION
for i = 1:length(s); disp(s(i)); end
           ID: 1
        TABLE: 'AEPOINT.PFT'
    ATTRIBUTE: 'AEPTTYPE'
        VALUE: 1
    DESCRIPTION: 'Active civil'

           ID: 2
        TABLE: 'AEPOINT.PFT'
    ATTRIBUTE: 'AEPTTYPE'
        VALUE: 2
    DESCRIPTION: 'Active civil and military'
   ID: 3
        TABLE: 'AEPOINT.PFT'
    ATTRIBUTE: 'AEPTTYPE'
        VALUE: 3
    DESCRIPTION: 'Active military'

           ID: 4
        TABLE: 'AEPOINT.PFT'
    ATTRIBUTE: 'AEPTTYPE'
        VALUE: 4
    DESCRIPTION: 'Other'

           ID: 5
        TABLE: 'AEPOINT.PFT'
    ATTRIBUTE: 'AEPTTYPE'
        VALUE: 5
    DESCRIPTION: 'Added from ONC when not available from DAFIF'
s = dcwread('NOAMER:DCW:NOAMER:AE:','AEPOINT.PFT',1)
s =
        ID: 1
    AEPTTYPE: 4
    AEPTNAME: 'THULE AIR BASE'
     AEPTVAL: 251
```

```
    AEPTDATE: '19900502000000000000'
    AEPTICAO: '1261'
    AEPTDKEY: 'BR17652'
     TILE_ID: 94
      END_ID: 1

s = dcwread('NOAMER:DCW:NOAMER:AE:','AEPOINT.PFT',{1,2})
s =
4678x1 struct array with fields:
    ID
    AEPTTYPE
```

See Also

dcwdata | dcwgaz | dcwrhead

dcwrhead

Purpose

Read DCW worldwide basemap file headers

Syntax

```
dcwrhead
dcwrhead(filepath,filename)
dcwrhead(filepath,filename,fid)
dcwrhead(...)
str = dcwrhead(...)
```

Description

`dcwrhead` allows the user to select the header file interactively.

`dcwrhead(filepath,filename)` reads from the specified file. The combination [`filepath filename`] must form a valid complete filename.

`dcwrhead(filepath,filename,fid)` reads from the already open file associated with `fid`.

`dcwrhead(...)` with no output arguments displays the formatted header information on the screen.

`str = dcwrhead(...)` returns a string containing the DCW header.

Background

The Digital Chart of the World (DCW) uses header strings in most files to document the contents and format of that file. This function reads the header string, displays a formatted version in the command window, or returns it as a string.

Tips

This function reads all DCW files except index files (files with names ending in `'X'`), thematic index files (files with names ending in `'TI'`), and spatial index files (files with names ending in `'SI'`).

File separators are platform dependent. The *`filepath`* input must use appropriate file separators, which you can determine using the MATLAB `filesep` function.

Examples

The following example uses the Macintosh file separators and pathname:

```
dcwrhead('NOAMER:DCW:NOAMER:AE:','AEPOINT.PFT')
Aeronautical Points
```

```
AEPOINT.DOC
ID=I,   1,P,Row Identifier,-,-,
AEPTTYPE=I,  1,N,Airport Type,INT.VDT,-,
AEPTNAME=T, 50,N,Airport Name,-,-,
AEPTVAL=I,  1,N,Airport Elevation Value,-,-,
AEPTDATE=D,  1,N,Aeronautical Information Date,-,-,
AEPTICAO=T,  4,N,International Civil Organization Number,-,-,
AEPTDKEY=T,  7,N,DAFIF Reference Number,-,-,
TILE_ID=S,  1,F,Tile Reference Identifier,-,AEPOINT.PTI,
END_ID=I  1,F,Entity Node Primitive Foreign Key,-,-,

s = dcwrhead('NOAMER:DCW:NOAMER:AE:','AEPOINT.PFT')
s =
;Aeronautical Points;AEPOINT.DOC;ID=I,   1,P,Row
Identifier,-,-,:AEPTTYPE=I,  1,N,Airport
Type,INT.VDT,-,:AEPTNAME=T, 50,N,Airport Name,-,-,:AEPTVAL=I,
1,N,Airport Elevation Value,-,-,:AEPTDATE=D,  1,N,Aeronautical
Information Date,-,-,:AEPTICAO=T,  4,N,International Civil
Organization Number,-,-,:AEPTDKEY=T,  7,N,DAFIF Reference
Number,-,-,:TILE_ID=S,  1,F,Tile Reference
Identifier,-,AEPOINT.PTI,:END_ID=I  1,F,Entity Node Primitive
Foreign Key,-,-,:;
```

See Also

dcwdata | dcwgaz | dcwread

defaultm

Purpose

Initialize or reset map projection structure

Syntax

```
mstruct = defaultm(projid)
mstruct = defaultm(mstruct)
```

Description

`mstruct = defaultm(projid)` initializes a map projection structure. The string `projid` should match one of the entries in the last column of the table displayed by the `maps` function. The output `mstruct` is a map projection structure. It is a scalar structure whose fields correspond to "Map Axes Object Properties" on page 3-51.

`mstruct = defaultm(mstruct)` checks an existing map projection structure, sets empty properties, and adjusts dependent properties. The `Origin`, `FLatLimit`, `FLonLimit`, `MapLatLimit`, and `MapLonLimit` properties may be adjusted for compatibility with each other and with the `MapProjection` property and (in the case of UTM or UPS) the `Zone` property.

With `defaultm`, you can construct a map projection structure (mstruct) that contains all the information needed to project and unproject geographic coordinates using `mfwdtran`, `minvtran`, `vfwdtran`, or `vintran` without creating a map axes or making any use at all of MATLAB graphics. Relevant parameters in the mstruct include the projection name, angle units, zone (for UTM or UPS), origin, aspect, false easting, false northing, and (for conic projections) the standard parallel or parallels. In very rare cases you might also need to adjust the frame limit (`FLatLimit` and `FLonLimit`) or map limit (`MapLatLimit` and `MapLonLimit`) properties.

You should make exactly two calls to `defaultm` to set up your mstruct, using the following sequence:

1. Construct a provisional version containing default values for the projection you've selected: `mstruct = defaultm(projection);`
2. Assign appropriate values to `mstruct.angleunits`, `mstruct.zone`, `mstruct.origin`, etc.

3 Set empty properties and adjust interdependent properties as needed to finalize your map projection structure: `mstruct = defaultm(mstruct);`

If you've set field *`prop1`* of mstruct to *`value1`*, field *`prop2`* to *`value2`*, and so forth, then the following sequence

```
mstruct = defaultm(projection);
mstruct.prop1 = value1;
mstruct.prop2 = value2;
...
mstruct = defaultm(mstruct);
```

produces exactly the same result as the following:

```
f = figure;
ax = axesm(projection, prop1, value1, prop2, value2, ...);
mstruct = getm(ax);
close(f)
```

but it avoids the use of graphics and is more efficient.

Note Angle-valued properties are in degrees by default. If you want to work in radians instead, you can make the following assignment in between your two calls to `defaultm`:

```
mstruct.angleunits = 'radians';
```

You must also use values in radians when assigning any angle-valued properties (such as `mstruct.origin`, `mstruct.parallels`, `mstruct.maplatlimit`, `mstruct.maplonlimit`, etc.).

See the Mapping Toolbox User's Guide section on "Working in UTM Without a Map Axes" for information and an example showing the use of `defaultm` in combination with UTM.

Examples

Create an empty map projection structure for a Mercator projection:

```
mstruct = defaultm('mercator')

mstruct =
     mapprojection: 'mercator'
              zone: []
        angleunits: 'degrees'
            aspect: 'normal'
      falseeasting: []
     falsenorthing: []
       fixedorient: []
             geoid: [1 0]
       maplatlimit: []
       maplonlimit: []
      mapparallels: 0
        nparallels: 1
            origin: []
       scalefactor: []
           trimlat: [-86 86]
           trimlon: [-180 180]
             frame: []
             ffill: 100
        fedgecolor: [0 0 0]
        ffacecolor: 'none'
         flatlimit: []
        flinewidth: 2
         flonlimit: []
              grid: []
         galtitude: Inf
            gcolor: [0 0 0]
        glinestyle: ':'
        glinewidth: 0.5000
    mlineexception: []
         mlinefill: 100
        mlinelimit: []
     mlinelocation: []
```

```
      mlinevisible: 'on'
    plineexception: []
         plinefill: 100
        plinelimit: []
     plinelocation: []
      plinevisible: 'on'
         fontangle: 'normal'
         fontcolor: [0 0 0]
          fontname: 'helvetica'
          fontsize: 9
         fontunits: 'points'
        fontweight: 'normal'
       labelformat: 'compass'
     labelrotation: 'off'
        labelunits: []
     meridianlabel: []
    mlabellocation: []
    mlabelparallel: []
       mlabelround: 0
     parallellabel: []
    plabellocation: []
    plabelmeridian: []
       plabelround: 0
```

Now change the map origin to `[0 90 0]`, and fill in default projection parameters accordingly:

```
mstruct.origin = [0 90 0];
mstruct = defaultm(mstruct)

mstruct =
     mapprojection: 'mercator'
              zone: []
        angleunits: 'degrees'
            aspect: 'normal'
      falseeasting: 0
     falsenorthing: 0
```

```
    fixedorient: []
          geoid: [1 0]
    maplatlimit: [-86 86]
    maplonlimit: [-90 270]
   mapparallels: 0
     nparallels: 1
         origin: [0 90 0]
    scalefactor: 1
        trimlat: [-86 86]
        trimlon: [-180 180]
          frame: 'off'
          ffill: 100
     fedgecolor: [0 0 0]
     ffacecolor: 'none'
      flatlimit: [-86 86]
     flinewidth: 2
      flonlimit: [-180 180]
           grid: 'off'
      galtitude: Inf
         gcolor: [0 0 0]
     glinestyle: ':'
     glinewidth: 0.5
mlineexception: []
     mlinefill: 100
    mlinelimit: []
 mlinelocation: 30
  mlinevisible: 'on'
plineexception: []
     plinefill: 100
    plinelimit: []
 plinelocation: 15
  plinevisible: 'on'
     fontangle: 'normal'
     fontcolor: [0 0 0]
      fontname: 'Helvetica'
      fontsize: 10
     fontunits: 'points'
```

```
        fontweight: 'normal'
       labelformat: 'compass'
     labelrotation: 'off'
        labelunits: 'degrees'
     meridianlabel: 'off'
    mlabellocation: 30
    mlabelparallel: 86
       mlabelround: 0
     parallellabel: 'off'
    plabellocation: 15
    plabelmeridian: -90
       plabelround: 0
```

See Also

axesm | gcm | mfwdtran | minvtran | setm

deg2km

Purpose

Convert distance from degrees to kilometers

Syntax

```
km = deg2km(deg)
km = deg2km(deg,radius)
km = deg2km(deg,sphere)
```

Description

`km = deg2km(deg)` converts distances from degrees to kilometers as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`km = deg2km(deg,radius)` converts distances from degrees to kilometers as measured along a great circle on a sphere having the specified radius. `radius` must be in units of kilometers.

`km = deg2km(deg,sphere)` converts distances from degrees to kilometers, as measured along a great circle on a sphere approximating an object in the Solar System. *`sphere`* may be one of the following strings: `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'earth'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, or `'pluto'`, and is case-insensitive.

See Also

`deg2nm` | `degtorad` | `deg2sm` | `km2deg` | `sm2deg`

Purpose

Convert distance from degrees to nautical miles

Syntax

```
nm = deg2nm(deg)
nm = deg2nm(deg,radius)
nm = deg2nm(deg,sphere)
```

Description

`nm = deg2nm(deg)` converts distances from degrees to nautical miles, as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`nm = deg2nm(deg,radius)` converts distances from degrees to nautical miles, as measured along a great circle on a sphere having the specified radius. `radius` must be in units of nautical miles.

`nm = deg2nm(deg,sphere)` converts distances from degrees to nautical miles, as measured along a great circle on a sphere approximating an object in the Solar System. *`sphere`* may be one of the following strings: `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'earth'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, or `'pluto'`, and is case-insensitive.

Examples

A degree of arc length is about 60 nautical miles:

```
deg2nm(1)

ans =
   60.0405
```

This is not true on Mercury, of course:

```
deg2nm(1,'mercury')

ans =
   22.9852
```

See Also

`degtorad` | `deg2sm` | `km2deg` | `sm2deg`

deg2sm

Purpose

Convert distance from degrees to statute miles

Syntax

```
sm = deg2sm(deg)
sm = deg2sm(deg,radius)
sm = deg2sm(deg,sphere)
```

Description

`sm = deg2sm(deg)` converts distances from degrees to statute miles, as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`sm = deg2sm(deg,radius)` converts distances from degrees to statute miles, as measured along a great circle on a sphere having the specified radius. `radius` must be in units of statute miles.

`sm = deg2sm(deg,sphere)` converts distances from degrees to statute miles, as measured along a great circle on a sphere approximating an object in the Solar System. *`sphere`* may be one of the following strings: `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'earth'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, or `'pluto'`, and is case-insensitive.

See Also

`deg2nm` | `degtorad` | `km2deg` | `sm2deg`

Purpose

Convert degrees to degrees-minutes

Syntax

```
DM = degrees2dm(angleInDegrees)
```

Description

`DM = degrees2dm(angleInDegrees)` converts angles from values in degrees which may include a fractional part (sometimes called "decimal degrees") to degree-minutes representation. The input should be a real-valued column vector. Given N-by-1 input, `DM` will be N-by-2, with one row per input angle. The first column of `DM` contains the "degrees" element and is integer-valued. The second column contains the "minutes" element and may have a nonzero fractional part. In any given row of `DM`, the sign of the first nonzero element indicates the sign of the overall angle. A positive number indicates north latitude or east longitude; a negative number indicates south latitude or west longitude. Any remaining elements in that row will have nonnegative values.

Examples

```
angleInDegrees = [ 30.8457722555556; ...
                  -82.0444189583333; ...
                   -0.504756513888889;...
                    0.004116666666667];
dm = degrees2dm(angleInDegrees)

dm =
  30.000000000000000  50.746335333336106
 -82.000000000000000   2.665137499997741
                   0 -30.285390833333338
                   0   0.247000000000020
```

See Also

`dm2degrees` | `degtorad` | `degrees2dms` | `radtodeg`

degrees2dms

Purpose

Convert degrees to degrees-minutes-seconds

Syntax

```
DMS = degrees2dms(angleInDegrees)
```

Description

`DMS = degrees2dms(angleInDegrees)` converts angles from values in degrees which may include a fractional part (sometimes called "decimal degrees") to degree-minutes-seconds representation. The input should be a real-valued column vector. Given N-by-1 input, `DMS` will be N-by-3, with one row per input angle. The first column of `DMS` contains the "degrees" element and is integer-valued. The second column contains the "minutes" element and is integer valued. The third column contains the "seconds" element, and can have a nonzero fractional part. In any given row of `DMS`, the sign of the first nonzero element indicates the sign of the overall angle. A positive number indicates north latitude or east longitude; a negative number indicates south latitude or west longitude. Any remaining elements in that row will have nonnegative values.

Examples

Convert four angles from values in degrees to degree-minutes-seconds representation.

```
format long g
angleInDegrees = [ 30.8457722555556; ...
                  -82.0444189583333; ...
                   -0.504756513888889; ...
                    0.004116666666667];
dms = degrees2dms(angleInDegrees)
```

The output appears as follows:

```
dms =
                30                50          44.7801200001663
               -82                 2          39.9082499998644
                 0               -30          17.1234500000003
                 0                 0          14.8200000000012
```

Convert angles to a string, with each angle on its own line.

```
nonnegative = all((dms >= 0),2);
hemisphere = repmat('N', size(nonnegative));
hemisphere(~nonnegative) = 'S';
absvalues = num2cell(abs(dms'));
values = [absvalues; num2cell(hemisphere')];
str = sprintf('%2.0fd%2.0fm%7.5fs%s\n', values{:})
```

The output appears as follows:

```
str =
    30d50m44.78012sN
    82d 2m39.90825sS
     0d30m17.12345sS
     0d 0m14.82000sN
```

Split the string into cells as delimited by the newline character, then return to the original values using `str2angle`.

```
newline = sprintf('\n');
C = textscan(str,'%s',-1,'delimiter',newline);
a = deal(C{:});
for k = 1:numel(a)
    str2angle(a{k})
end
```

The output appears as follows:

```
ans =
          30.8457722555556

ans =
         -82.0444189583333

ans =
        -0.504756513888889

ans =
```

```
0.00411666666666667
```

See Also

dms2degrees | degtorad | degrees2dm | radtodeg

Purpose

Convert angles from degrees to radians

Syntax

```
angleInRadians = degtorad(angleInDegrees)
```

Description

`angleInRadians = degtorad(angleInDegrees)` converts angle units from degrees to radians. This is both an angle conversion function and a distance conversion function, since arc length can be a measure of distance in either radians or degrees, provided that the radius is known.

Examples

Show that there are 2π radians in a full circle:

```
2*pi - degtorad(360)

ans =
     0
```

See Also

`fromDegrees` | `fromRadians` | `toDegrees` | `toRadians` | `radtodeg`

demcmap

Purpose

Colormaps appropriate to terrain elevation data

Syntax

```
demcmap(Z)
demcmap(Z,ncolors)
demcmap(Z,ncolors,cmapsea,cmapland)

demcmap('inc',Z,deltaz)
demcmap('inc',Z,deltaz,cmapsea,cmapland)

[cmap,climits] = demcmap( ___ )
```

Description

`demcmap(Z)` sets the colormap and color axis limits based on the elevation data limits derived from input argument `Z`.

- The default colormap assigns shades of green and brown for positive elevations, and various shades of blue for negative elevation values below sea level.
- The number of colors assigned to land and to sea are in proportion to the ranges in terrain elevation and bathymetric depth and total 64 by default. The color axis limits are computed such that the interface between land and sea maps to the zero elevation contour.
- The colormap is applied to the current figure and the color axis limits are applied to the current axes.

`demcmap(Z,ncolors)` creates a colormap of length `ncolors`.

`demcmap(Z,ncolors,cmapsea,cmapland)` assigns `cmapsea` and `cmapland` to elevations below and above sea level respectively.

`demcmap('inc',Z,deltaz)` chooses number of colors and color axis limits such that each color approximately represents the increment of elevation `deltaz`.

- The literal string `'inc'` signals `demcmap` that the first argument after `Z` will be `deltaz`.

`demcmap('inc',Z,deltaz,cmapsea,cmapland)` assigns `cmapsea` and `cmapland` to elevations below and above sea level respectively.

`[cmap,climits] = demcmap( ___ )` returns colormap `cmap` and color axis limit `climits`, using any of the above syntaxes, but does not apply them to figure or axes properties.

- Even if only one output argument is specified, no change occurs to figure or axes properties.

Input Arguments

Z - Terrain elevation limits

vector | matrix

Terrain elevation limits specified as a vector or matrix. If `Z` is a 2 element vector, then it specifies the minimum and maximum limits of terrain elevation data; ordering is not important. If `Z` is a matrix, then it specifies an elevation grid in which positive and negative values represent points above and below sea level respectively.

```
load topo
worldmap('world')
meshm(topo,topolegend)
Zlimits = [min(topo(:)) max(topo(:))];
Zgrid = topo;
demcmap(Zlimits);
demcmap(Zgrid)
```

The above two syntaxes for `demcmap` are identical in their effect on the figure colormap and axes properties.

Data Types

single | double | int8 | int32 | uint8 | uint16 | uint32

ncolors - Number of colors in colormap

64 (default) | scalar

Number of colors in the colormap specified as a scalar. It defines the number of rows `m` in the mx3 RGB matrix of the figure colormap.

Data Types
double

cmapsea,cmapland - RGB colormap matrices

matrix

- RGB colormaps specified as mx3 arrays containing any number of rows. The two colormaps need not be equal in length. They serve as the basis set for populating the figure colormap by interpolation.
- `cmapsea` and `cmapland` replace the default colormap. The default colormap for land or sea can be retained by providing an empty matrix in place of either colormap matrix.

That part of the figure colormap assigned to negative elevations is derived from `cmapssea`; `cmapland` plays a similar role for positive elevations.

Data Types
double

deltaz - Increment of elevation

scalar

The increment of elevation specified as a scalar. The color quantization of the default or user supplied colormap is adjusted such that each discrete color approximately represents a `deltaz` increment in elevation.

Data Types
double

Output Arguments

cmap - RGB colormap

matrix

RGB colormap returned as a matrix constructed for the figure colormap. Supply output arguments when you want to obtain the colormap and color axis limits without applying them automatically to the figure or axes properties. These properties remain unchanged even if only one output (`cmap`) is specified.

Data Types
double

climits - Color axis limits

vector

Color axis limits returned as a vector. `climits` may differ somewhat from those derived from input argument `Z` due to the quantization which results from fitting a limited number of colors over the range limit of the elevation data.

Supply output arguments when you want to obtain the colormap and color axis limits without applying them automatically to the figure or axes.

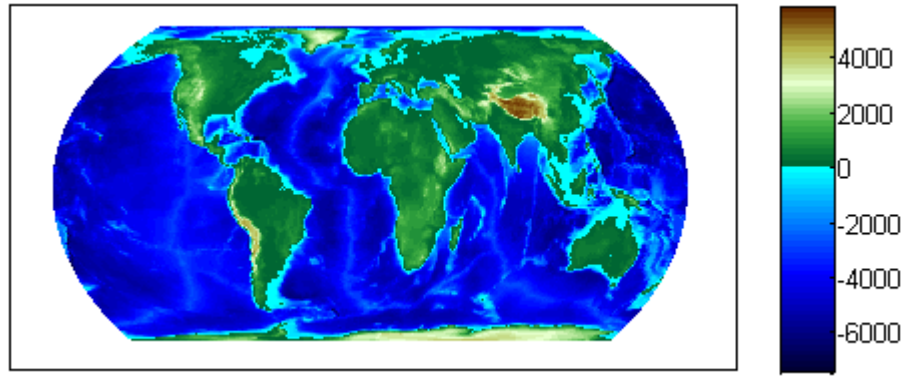
Data Types
double

Examples

Displaying Elevation Data With Default Colormap

Explicitly determine maximum and minimum values of elevation data matrix

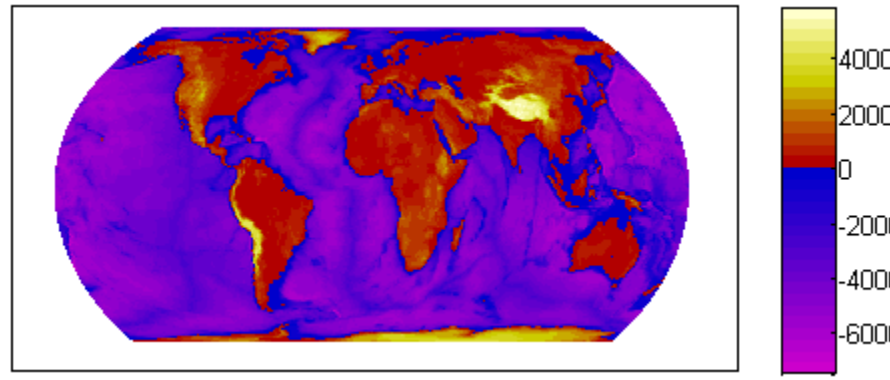
```
load topo
axesm hatano
meshm(topo,topolegend)
zlimits = [min(topo(:)) max(topo(:))];
demcmap(zlimits);
colorbar;
```



Defining Custom Land And Sea Colormaps

Custom RGB colormaps, `cmapssea`; `cmapland` , of differing lengths are used to populate figure colormap by interpolation. The colors in each colormap map to the land and sea regions of the map. Fewer colors have been specified in total than the default number of 64. `demcmap` determines maximum and minimum elevation data limits internally as shown in the below example when the first argument is the elevation data grid.

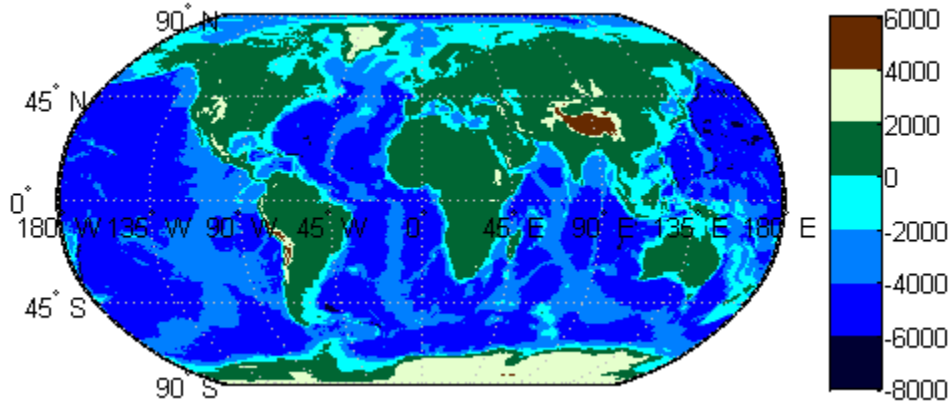
```
load topo   % grid of elevation data
axesm hatano
meshm(topo,topolegend)
cmapsea  = [.8  0 .8;  0 0 .8];
cmapland = [.7  0  0; .8 .8 0; 1  1 .8 ];
demcmap(topo,32,cmapsea,cmapland)
colorbar;
```



Colormap in Which Each Color Approximates a User Defined Increment

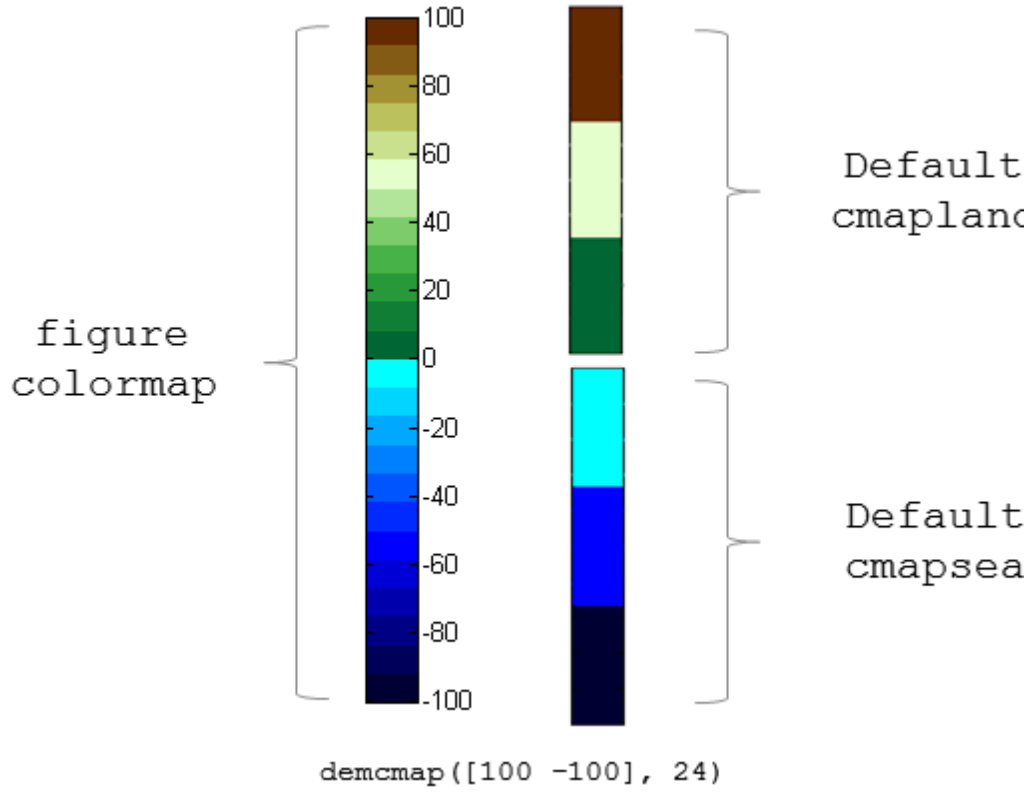
The following `demcmap` example controls the color quantization by choosing an optimal number of colors such that each color represents an elevation increment of approximately 2000 .

```
load topo
R = georasterref('RasterSize', size(topo),'Latlim', [-90 90], 'Lonlim
figure('Color','white')
worldmap('world')
geoshow(topo, R, 'DisplayType', 'texturemap')
demcmap('inc',[max(topo(:)) min(topo(:))],2000);
colorbar
```



Algorithms

If the elevation grid data contains both positive and negative values, then the computed colormap, `cmap`, has a “sea” partition of length `nsea` and "land" partition of length `nland`. The sum of `nsea` and `nland` equals the total number of entries in the computed colormap. The actual values of `nsea` and `nland` depend upon the number of entries and the relative range of the negative and positive limits of the elevation data. The sea partition consists of rows 1 through `nsea`, and the land partition consists of rows `nsea` + 1 through `ncolors`. The sea and land partitions of the figure colormap are populated with colors interpolated from the basis RGB colormaps, `cmapsea` and `cmapland`. In the figure below, the sea and land 3x3 RGB colormaps shown are the default colors used by `demcmap` to populate the figure colormap when no user specified colormaps are provided.



If the elevation grid data contains only positive or negative values, then the figure colormap is derived solely from the corresponding sea or land colormap.

See Also

`caxis` | `colormap` | `meshlrm` | `meshm` | `surflsrm` | `surfm`

departure

Purpose

Departure of longitudes at specified latitudes

Syntax

```
dist = departure(long1,long2,lat)
dist = departure(long1,long2,lat,ellipsoid)
dist = departure(long1,long2,lat,units)
dist = departure(long1,long2,lat,geoid,units)
```

Description

`dist = departure(long1,long2,lat)` computes the departure distance from `long1` to `long2` at the input latitude `lat`. Departure is the distance along a specific parallel between two meridians. The output `dist` is returned in degrees of arc length on a sphere.

`dist = departure(long1,long2,lat,ellipsoid)` computes the departure assuming that the input points lie on the ellipsoid defined by the input `ellipsoid`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`.

`dist = departure(long1,long2,lat,units)` uses the input string *`units`* to define the angle units of the input and output data. In this form, the departure is returned as an arc length in the units specified by *`units`*. If *`units`* is omitted, `'degrees'` is assumed.

`dist = departure(long1,long2,lat,geoid,units)` is a valid calling form. In this case, the departure is computed in the same units as the semimajor axes of the ellipsoid.

Definitions

Departure is the distance along a parallel between two points. Whereas a degree of latitude is always the same distance, a degree of longitude is different in length at different latitudes. In practice, this distance is usually given in nautical miles.

Examples

On a spherical Earth, the departure is proportional to the cosine of the latitude:

```
distance = departure(0, 10, 0)

distance =
```

```
    10

distance = departure(0, 10, 60)

distance =
     5
```

When an ellipsoid is used, the result is more complicated. The distance at 60º is not exactly twice the 0º value:

```
distance = departure(0, 10, 0, referenceEllipsoid('earth', 'nm'))

distance =
  601.0772
distance = departure(0, 10, 60, referenceEllipsoid('earth', 'nm'))

distance =
  299.7819
```

See Also

distance | stdm

displaym

Purpose

Display geographic data from display structure

Syntax

```
displaym(displaystruct)
displaym(displaystruct,str)
displaym(displaystruct,strings)
displaym(displaystruct,strings,searchmethod)
h = displaym(displaystruct)
```

Description

`displaym(displaystruct)` projects the data contained in the input `displaystruct`, a Version 1 Mapping Toolbox display structure, in the current axes. The current axes must be a map axes with a valid map definition. See the remarks about "Version 1 Display Structures" on page 3-177 below for details on the contents of display structures.

`displaym(displaystruct,str)` displays the vector data elements of `displaystruct` whose `'tag'` fields contains strings beginning with the string `str`. Vector data elements are those whose `'type'` field is either `'line'` or `'patch'`. The string match is case-insensitive.

`displaym(displaystruct,strings)` displays the vector data elements of `displaystruct` whose `'tag'` field matches begins with one of the elements (or rows) of `strings`. `strings` is a cell array of strings (or a 2-D character array). In the case of character array, trailing blanks are stripped from each row before matching.

`displaym(displaystruct,strings,searchmethod)` controls the method used to match the values of the `tag` field in `displaystruct`, as follows:

- `'strmatch'` — Search for matches at the beginning of the tag
- `'findstr'` — Search within the tag
- `'exact'` — Search for exact matches

Note that when `searchmethod` is specified the search is case-sensitive.

`h = displaym(displaystruct)` returns handles to the graphic objects created by `displaym`.

Note The type of *display structure* accepted by `displaym` is not the same as a *geographic data structure* (geostructs and mapstructs). introduced in Mapping Toolbox Version 2. Use `geoshow` or `mapshow` instead of `displaym` to display geostructs or mapstructs—created using `shaperead` and `gshhs`, for example. For more information, see "Mapping Toolbox Geographic Data Structures".

Tips

The following section documents the contents of display structures.

Version 1 Display Structures

A display structure is a MATLAB structure array with a specific set of fields:

- A `tag` field names an individual feature or object
- A `type` field specifies a MATLAB graphics object type (`'line'`, `'patch'`, `'surface'`, `'text'`, or `'light'`) or has the value `'regular'`, specifying a regular data grid
- `lat` and `long` fields contain coordinate vectors of latitudes and longitudes, respectively
- An `altitude` field contains a vector of vertical coordinate values
- A `string` property contains text to be displayed if `type` is `'text'`
- MATLAB graphics properties are specified explicitly, on a per-feature basis, in an `otherproperty` field

The choice of options for the `type` field reveals that a display structure can contain

- Vector geodata (`type` is `'line'` or `'patch'`)
- Raster geodata (`type` is `'surface'` or `'regular'`)
- Graphic objects (`type` is `'text'` or `'light'`)

The following table indicates which fields are used in the six types of display structures:

Field Name	Type 'light'	Type 'line'	Type 'patch'	Type 'regular'	Type 'surface'	Type 'text'
type	•	•	•	•	•	•
tag	•	•	•	•	•	•
lat	•	•	•		•	•
long	•	•	•		•	•
map				•	•	
maplegend				•		
meshgrat				•		
string						•
altitude	•	•	•	•	•	•
otherproperty	•	•	•	•	•	•

Some fields can contain empty entries, but each indicated field must exist for the objects in the struct array to be displayed correctly. For instance, the `altitude` field can be an empty matrix and the `otherproperty` field can be an empty cell array.

The `type` field must be one of the specified map object types: `'line'`, `'patch'`, `'regular'`, `'surface'`, `'text'`, or `'light'`.

The `tag` field must be a string different from the `type` field usually containing the name or kind of map object. Its contents must not be equal to the name of the object type (i.e., line, surface, text, etc.).

The `lat`, `long`, and `altitude` fields can be scalar values, vectors, or matrices, as appropriate for the map object type.

The `map` field is a data grid. If `map` is a regular data grid, `maplegend` is its corresponding referencing vector, and `meshgrat` is a two-element vector specifying the graticule mesh size. If `map` is a geolocated data grid, `lat` and `long` are the matrices of latitude and longitude coordinates.

The `otherproperty` field is a cell array containing any additional display properties appropriate for the map object. Cell array entries can

be a line specification string, such as `'r+'`, or property name/property value pairs, such as `'color','red'`. If the `otherproperty` field is left as an empty cell array, default colors are used in the display of lines and patches based on the `tag` field.

Note In some cases you can use the `geoshow` function as a direct alternative to `displaym`. It accepts display structures of type `line` and `patch`.

See Also

`extractm` | `geoshow` | `mapshow` | `mlayers` | `updategeostruct`

dist2str

Purpose

Format distance strings

Syntax

```
str = dist2str(distin)
str = dist2str(dist,format)
str = dist2str(dist,format,units)
str = dist2str(dist,format,digits)
str = dist2str(dist,format,units,digits)
```

Description

`str = dist2str(distin)` converts a numerical vector of distances in kilometers, `distin`, to a string matrix. The output string matrix is useful for the display of distances.

`str = dist2str(dist,format)` uses the *`format`* string to specify the notation to be used for the string matrix. If blank or `'none'`, the result is a simple numerical representation (no indicator for positive distances, minus signs for negative distances). The only other format is `'pm'` (for *plus-minus*) prefixes a + for positive distances.

`str = dist2str(dist,format,units)` defines the units in which the input distances are supplied, and which are encoded in the string matrix. Units must be one of the following: `'feet'`, `'kilometers'`, `'meters'`, `'nauticalmiles'`, `'statutemiles'`, `'degrees'`, or `'radians'`. Note that statute miles are encoded as `'mi'` in the string matrix, whereas in most Mapping Toolbox functions, `'mi'` indicates international miles. If omitted or blank, `'kilometers'` is assumed.

`str = dist2str(dist,format,digits)` or `str = dist2str(dist,format,units,digits)` uses the input `digits` to determine the number of decimal digits in the output matrix. `digits = -2` uses accuracy in the hundredths position, `digits = 0` uses accuracy in the units position. Default is `digits = -2`. For further discussion of specifying `digits`, see `roundn`.

The purpose of this function is to make distance-valued variables into strings suitable for map display.

Examples

Create a vector of values and convert to strings:

```
d = [-3.7 2.95 87];
```

```
str = dist2str(d,'none','km')

str =
-3.70 km
 2.95 km
87.00 km
```

Now change the units to nautical miles, add plus signs to positive values, and truncate to the tenths (10^{-1}) slot:

```
str = dist2str(d,'pm','nm',-1)

str =
 -3.7 nm
 +3.0 nm
+87.0 nm
```

See Also

angl2str | roundn

distance

Purpose

Distance between points on sphere or ellipsoid

Syntax

```
[arclen,az] = distance(lat1,lon1,lat2,lon2)
[arclen,az] = distance(lat1,lon1,lat2,lon2,ellipsoid)
[arclen,az] = distance(lat1,lon1,lat2,lon2,units)
[arclen,az] = distance(lat1,lon1,lat2,lon2,ellipsoid,units)
[arclen,az] = distance(track,...)
[arclen,az] = distance(pt1,pt2)
[arclen,az] = distance(pt1,pt2,ellipsoid)
[arclen,az] = distance(pt1,pt,units)
[arclen,az] = distance(pt1,pt2,ellipsoid,units)
[arclen,az] = distance(track,pt1,...)
```

Description

`[arclen,az] = distance(lat1,lon1,lat2,lon2)` computes the lengths, `arclen`, of the great circle arcs connecting pairs of points on the surface of a sphere. In each case, the shorter (minor) arc is assumed. The function can also compute the azimuths, `az`, of the second point in each pair with respect to the first (that is, the angle at which the arc crosses the meridian containing the first point). The input latitudes and longitudes, `lat1`, `lon1`, `lat2`, `lon2`, can be scalars or arrays of equal size and must be expressed in degrees. `arclen` is expressed in degrees of arc and will have the same size as the input arrays. `az` is measured clockwise from north, in units of degrees. When given a combination of scalar and array inputs, the scalar inputs are automatically expanded to match the size of the arrays.

`[arclen,az] = distance(lat1,lon1,lat2,lon2,ellipsoid)` computes geodesic arc length and azimuth assuming that the points lie on the reference ellipsoid defined by the input `ellipsoid`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The output, `arclen`, is expressed in the same length units as the semimajor axis of the ellipsoid.

`[arclen,az] = distance(lat1,lon1,lat2,lon2,`*`units`*`)` uses the input string `units` to define the angle unit of the outputs `arclen` and `az` and the input latitude-longitude coordinates. `units` may equal `'degrees'` (the default value) or `'radians'`.

`[arclen,az] = distance(lat1,lon1,lat2,lon2,ellipsoid,`*`units`*`)` uses the `units` string to specify the units of the latitude-longitude coordinates, but the output range has the same units as the semimajor axis of the ellipsoid.

`[arclen,az] = distance(track,...)` uses the input string `track` to specify either a great circle/geodesic or a rhumb line arc. If `track` equals `'gc'` (the default value), then great circle distances are computed on a sphere and geodesic distances are computed on an ellipsoid. If `track` equals `'rh'`, then rhumb line distances are computed on either a sphere or ellipsoid.

`[arclen,az] = distance(pt1,pt2)` accepts *N*-by-2 coordinate arrays `pt1` and `pt2` such that `pt1 = [lat1 lon1]` and `pt2 = [lat2 lon2]`, where `lat1`, `lon1`, `lat2`, and `lon2` are column vectors. It is equivalent to `arclen = distance(pt1(:,1),pt1(:,2),pt2(:,1),pt2(:,2))`.

`[arclen,az] = distance(pt1,pt2,ellipsoid)`,

`[arclen,az] = distance(pt1,pt,units)`,

`[arclen,az] = distance(pt1,pt2,ellipsoid,units)`, and

`[arclen,az] = distance(track,pt1,...)` are all valid calling forms.

Examples

Using `pt1,pt2` notation, find the distance from Norfolk, Virginia (37ºN, 76ºW), to Cape St. Vincent, Portugal (37ºN, 9ºW), just outside the Straits of Gibraltar. The distance between these two points depends upon the *`track`* string selected.

```
arclen = distance('gc',[37,-76],[37,-9])

arclen =
   52.3094

arclen = distance('rh',[37,-76],[37,-9])

arclen =
    53.5086
```

The difference between these two tracks is 1.1992 degrees, or about 72 nautical miles. This represents about 2% of the total trip distance. The trade-off is that at the cost of those 72 miles, the entire trip can be made on a rhumb line with a fixed course of 90º, due east, while in order to follow the shorter great circle path, the course must be changed continuously.

On a meridian and on the Equator, great circles and rhumb lines coincide, so the distances are the same. For example,

```
% Great circle distance
arclen = distance(37,-76,67,-76)

arclen =
     30.0000

% Rhumb line distance
arclen = distance('rh',37,-76,67,-76)

arclen =
     30.0000
```

The distances are the same, 30º, or about 1800 nautical miles. (There are about 60 nautical miles in a degree of arc length.)

Algorithms

Distance calculations for geodesics degrade slowly with increasing distance and may break down for points that are nearly antipodal, as well as when both points are very close to the Equator. In addition, for calculations on an ellipsoid, there is a small but finite input space, consisting of pairs of locations in which both the points are nearly antipodal *and* both points fall close to (but not precisely on) the Equator. In this case, a warning is issued and both `arclen` and `az` are set to NaN for the "problem pairs."

Alternatives

Distance between two points can be calculated in two ways. For great circles (on the sphere) and geodesics (on the ellipsoid), the distance is the shortest surface distance between two points. For rhumb lines, the

distance is measured along the rhumb line passing through the two points, which is not, in general, the shortest surface distance between them.

When you need to compute both distance and azimuth for the same point pair(s), it is more efficient to do so with a single call to `distance`. That is, use

```
[arclen az] = distance(...);
```

rather than the slower

```
arclen = distance(...)
az = azimuth(...)
```

To express the output `arclen` as an arc length in either degrees or radians, omit the `ellipsoid` argument. This is possible only on a sphere. If `ellipsoid` is supplied, `arclen` is a distance expressed in the same units as the semimajor axis of the ellipsoid. Specify `ellipsoid` as `[R 0]` to compute `arclen` as a distance on a sphere of radius `R`, with `arclen` having the same units as `R`.

See Also

`referenceEllipsoid` | `referenceSphere` | `oblateSpheroid` | `azimuth` | `elevation` | `reckon` | `track` | `track1` | `track2` | `trackg`

How To

- "Great Circles, Rhumb Lines, and Small Circles"

distortcalc

Purpose

Distortion parameters for map projections

Syntax

```
areascale = distortcalc(lat,long)
areascale = distortcalc(mstruct,lat,long)
[areascale,angdef,maxscale,minscale,merscale,
   parscale] =  distortcalc(...)
```

Description

`areascale = distortcalc(lat,long)` computes the area distortion for the current map projection at the specified geographic location. An area scale of 1 indicates no scale distortion. Latitude and longitude can be scalars, vectors, or matrices in the angle units of the defined map projection.

`areascale = distortcalc(mstruct,lat,long)` uses the projection defined in the map structure `mstruct`.

`[areascale,angdef,maxscale,minscale,merscale,parscale] = distortcalc(...)` computes the area scale, maximum angular deformation of right angles (in the angle units of the defined projection), the particular maximum and minimum scale distortions in any direction, and the particular scale along the meridian and parallel. You can also call `distortcalc` with fewer output arguments, in the order shown.

Background

Map projections inevitably introduce distortions in the shapes and sizes of objects as they are transformed from three-dimensional spherical coordinates to two-dimensional Cartesian coordinates. The amount and type of distortion vary between projections, over the projection, and with the selection of projection parameters such as standard parallels. This function allows a quantitative evaluation of distortion parameters.

Examples

At the equator, the Mercator projection is free of both area and angular distortion:

```
axesm mercator
[areascale,angdef] = distortcalc(0,0)
```

```
areascale =
      1.0000
angdef =
      8.5377e-007
```

At 60 degrees north, objects are shown at 400% of their true area. The projection is conformal, so angular distortion is still zero.

```
[areascale,angdef] = distortcalc(60,0)

areascale =
       4.0000
angdef =
     4.9720e-004
```

Tips

This function uses a finite difference technique. The geographic coordinates are perturbed slightly in different directions and projected. A small amount of error is introduced by numerical computation of derivatives and the variation of map distortion parameters.

See Also

`mdistort` | `tissot`

distdim

Purpose

Convert length units

Syntax

```
distOut = distdim(distIn,from,to)
distOut = distdim(distIn,from,to,radius)
distOut = distdim(distIn,from,to,sphere)
```

Note `distdim` has been replaced by `unitsratio`, but will be maintained for backward compatibility. See "Replacing distdim" on page 3-190 for details.

Description

`distOut = distdim(distIn,from,to)` converts `distIn` from the units specified by the string *`from`* to the units specified by the string *`to`*. *`from`* and *`to`* are case-insensitive, and may equal any of the following:

`'meters'` or `'m'`	
`'feet'` or `'ft'`	U.S. survey feet
`'kilometers'` or `'km'`	
`'nauticalmiles'` or `'nm'`	
`'miles'`, `'statutemiles'`, `'mi'`, or `'sm'`	Statute miles
`'degrees'` or `'deg'`	
`'radians'` or `'rad'`	

If either *`from`* or *`to`* indicates angular units (`'degrees'` or `'radians'`), the conversion to or from linear distance is made along a great circle arc on a sphere with a radius of 6371 km, the mean radius of the Earth.

`distOut = distdim(distIn,from,to,radius)`, where one of the unit strings, either *`from`* or *`to`*, indicates angular units and the other unit string indicates length units, uses a great circle arc on a sphere of the given radius. The specified length units must apply to `radius` as well as to the input distance (when *`from`* indicates length) or output distance (when *`to`* indicates length). If neither *`from`* nor *`to`* indicates angular units, or if both do, then the value of `radius` is ignored.

`distOut = distdim(distIn,from,to,sphere)`, where either *`from`* or *`to`* indicates angular units, uses a great circle arc on a sphere approximating a body in the Solar System. *`sphere`* may be one of the following strings: `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'earth'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, or `'pluto'`, and is case-insensitive. If neither *`to`* nor *`from`* is angular, *`sphere`* is ignored.

Tips

Arc Lengths of Angles Not Constant

Distance is expressed in one of two general forms: as a linear measure in some unit (kilometers, miles, etc.) or as angular arc length (degrees or radians). While the use of linear units is generally understood, angular arc length is not always as clear. The conversion from angular units to linear units for the arc along any circle is the angle in radians multiplied by the radius of the circle. On the sphere, this means that radians of latitude are directly translatable to kilometers, say, by multiplying by the radius of the Earth in kilometers (about 6,371 km). However, the linear distance associated with radians of longitude changes with latitude; the radius in question is then not the radius of the Earth, but the (chord) radius of the small circle defining that parallel. The angle in radians or degrees associated with any distance is the arc length of a great circle passing through the points of interest. Therefore, the radius in question always refers to the radius of the relevant sphere, consistent with the `distance` function.

Exercise Caution with 'feet' and 'miles'

Exercise caution with 'feet' and 'miles'. `distdim` interprets `'feet'` and `'ft'` as U.S. survey feet, and does not support international feet at all. In contrast, `unitsratio` follows the opposite, and more standard approach, interpreting both `'feet'` and `'ft'` as international feet. `unitsratio` provides separate options, including `'surveyfeet'` and `'sf'`, to indicate survey feet. By definition, one international foot is exactly 0.3048 meters and one U.S. survey foot is exactly 1200/3937 meters. For many applications, the difference is significant. Most projected coordinate systems use either the meter or the survey foot as a standard unit. International feet are less likely to be used, but do occur sometimes. Likewise, `distdim` interprets `'miles'` and `'mi'` as

statute miles (also known as U.S. survey miles), and does not support international miles at all. By definition, one international mile is 5,280 international feet and one statute mile is 5,280 survey feet. You can evaluate:

```
unitsratio('millimeter','statute mile') - ...
    unitsratio('millimeter','mile')
```

to see that the difference between a statute mile and an international mile is just over three millimeters. This may seem like a very small amount over the length of a single mile, but mixing up these units could result in a significant error over a sufficiently long baseline. Originally, the behavior of `distdim` with respect to `'miles'` and `'mi'` was documented only indirectly, via the now-obsolete `unitstr` function. As with feet, `unitsratio` takes a more standard approach. `unitsratio` interprets `'miles'` and `'mi'` as international miles, and `'statute miles'` and `'sm'` as statute miles. (`unitsratio` accepts several other strings for each of these units; see the `unitsratio` help for further information.)

Replacing distdim

If both *`from`* and *`to`* are known at the time of coding, then you may be able to replace `distdim` with a direct conversion utility, as in the following examples:

`distdim(dist,'nm',km')`	⇒ `nm2km(dist)`
`distdim(dist,'sm','deg')`	⇒ `sm2deg(dist)`
`distdim(dist, 'rad', 'km', 'moon')`	⇒ `rad2km(dist,'moon')`

If the there is no appropriate direct conversion utility, or you won't know the valus of *`from`* and/or *`to`* until run time, you can generally replace

```
distdim(dist, FROM, TO)
```

with

```
unitsratio(TO, FROM) * dist
```

If you are using units of feet or miles, see the cautionary note above about how they are interpreted. For example, with `distIn` in meters and `distOut` in survey feet, `distOut = distdim(distIn, 'meters', 'feet')` should be replaced with `distOut = unitsratio('survey feet','meters') * distIn`. Saving a multiplicative factor computed with `unitsratio` and using it to convert in a separate step can make code cleaner and more efficient than using `distdim`. For example, replace

```
dist1_meters = distdim(dist1_nm, 'nm', 'meters');
dist2_meters = distdim(dist2_nm, 'nm', 'meters');
```

with

```
metersPerNM = unitsratio('meters','nm');
dist1_meters = metersPerNM * dist1_nm;
dist2_meters = metersPerNM * dist2_nm;
```

`unitsratio` does not perform great-circle conversion between units of length and angle, but it can be easily combined with other functions to do so. For example, to convert degrees to meters along a great-circle arc on a sphere approximating the planet Mars, you could replace

```
 distdim(dist, 'degrees', 'meters', 'mars')
```

with

```
 unitsratio('meters','km') * deg2km(dist, 'mars')
```

Examples

Convert 100 kilometers to nautical miles:

```
distkm = 100

distkm =
```

```
   100

distnm = distdim(distkm,'kilometers','nauticalmiles')

distnm =
   53.9957
```

A degree of arc length is about 60 nautical miles:

```
distnm = distdim(1,'deg','nm')

distnm =
   60.0405
```

This is not accidental. It is the original definition of the nautical mile. Naturally, this assumption does not hold on other planets:

```
distnm = distdim(1,'deg','nm','mars')

distnm =
   31.9474
```

See Also

deg2km | deg2nm | deg2sm | km2deg | km2nm | km2rad | km2sm | nm2deg | nm2km | nm2rad | nm2sm | rad2km | rad2nm | rad2sm | sm2deg | sm2km | sm2nm | sm2rad | unitsratio

Purpose

Convert degrees-minutes to degrees

Syntax

```
angleInDegrees = dm2degrees(DM)
```

Description

`angleInDegrees = dm2degrees(DM)` converts angles from degree-minutes representation to values in degrees which may include a fractional part (sometimes called "decimal degrees"). `DM` should be N-by-2 and real-valued, with one row per angle. The output will be an N-by-1 column vector whosek^{th} element corresponds to the k^{th} row of `DM`. The first column of `DM` contains the "degrees" element and should be integer-valued. The second column contains the "minutes" element and may have a fractional part For an angle that is positive (north latitude or east longitude) or equal to zero, all elements in the row need to be nonnegative. For a negative angle (south latitude or west longitude), the first nonzero element in the row should be negative and the remaining value, if any, should be nonzero. Thus, for an input row with value `[D M]`, with integer-valued `D` and real `M`, the output value will be

```
SGN * (abs(D) + abs(M)/60)
```

where `SGN` is 1 if `D` and `M` are both nonnegative and -1 if the first nonzero element of `[D M]` is negative (an error results if a nonzero `D` is followed by a negative `M`). Any fractional parts in the first (degrees) columns of `DM` are ignored. An error results unless the absolute values of all elements in the second (minutes) column are less than 60.

Examples

```
dm = [ ...
       30  44.78012; ...
      -82  39.90825; ...
        0 -17.12345; ...
        0  14.82000];
format long g
angleInDegrees = dm2degrees(dm)

angleInDegrees =
          30.7463533333333
               -82.6651375
```

```
-0.285390833333333
                0.247
```

See Also

degrees2dm | degtorad | dms2degrees | str2angle

Purpose

Convert degrees-minutes-seconds to degrees

Syntax

```
angleInDegrees = dms2degrees(DMS)
```

Description

`angleInDegrees = dms2degrees(DMS)` converts angles from degree-minutes-seconds representation to values in degrees which may include a fractional part (sometimes called "decimal degrees"). `DMS` should be N-by-3 and real-valued, with one row per angle. The output will be an N-by-1 column vector whose k^{th} element corresponds to the k^{th} row of `DMS`. The first column of `DMS` contains the "degrees" element and should be integer-valued. The second column contains the "minutes" element and should be integer-valued. The third column contains the "seconds" element and may have a fractional part. For an angle that is positive (north latitude or east longitude) or equal to zero, all elements in the row need to be nonnegative. For a negative angle (south latitude or west longitude), the first nonzero element in the row should be negative and the remaining values should be positive. Thus, for an input row with value `[D M S]`, with integer-valued `D` and `M`, and real `D`, `M`, and `S`, the output value will be

```
SGN * (abs(D) + abs(M)/60 + abs(S)/3600)
```

where `SGN` is 1 if `D`, `M`, and `S` are all nonnegative and -1 if the first nonzero element of `[D M S]` is negative (an error results if a nonzero element is followed by a negative element). Any fractional parts in the first (degrees) and second (minutes) columns of `DMS` are ignored. An error results unless the absolute values of all elements in the second (minutes) and third (seconds) columns are less than 60.

Examples

```
dms = [ ...
            30  50 44.78012; ...
           -82   2 39.90825; ...
             0 -30 17.12345; ...
             0   0 14.82000];
format long g
angleInDegrees = dms2degrees(dms)
```

```
angleInDegrees =
          30.8457722555556
         -82.0444189583333
        -0.504756513888889
       0.00411666666666667
```

See Also

degrees2dm | degtorad | dm2degrees | str2angle

Purpose

Dead reckoning positions for track

Syntax

```
[drlat,drlong,drtime] = dreckon(waypoints,time,speed)
[drlat,drlong,drtime] = dreckon (waypoints,time,speed,
   spdtimes)
```

Description

`[drlat,drlong,drtime] = dreckon(waypoints,time,speed)` returns the positions and times of required dead reckoning (DR) points for the input track that starts at the input time. The track should be in navigational track format (two columns, latitude then longitude, in order of traversal). These waypoints are the starting and ending points of each leg of the track. There is one fewer track leg than waypoints, as the last point included is the end of the track. In navigation, the first waypoint would be a navigational fix, taken at `time`. The `speed` input can be a scalar, in which case a constant speed is used throughout, or it can be a vector in which one speed is given for each track leg (that is, speed changes coincide with course changes).

`[drlat,drlong,drtime] = dreckon (waypoints,time,speed,spdtimes)` allows speed changes to occur independent of course changes. The elements of the `speed` vector must have a one-to-one correspondence with the elements of the `spdtimes` vector. This latter variable consists of the time interval after `time` at which each speed order *ends*. For example, if `time` is 6.75, and the first element of `spdtimes` is 1.35, then the first `speed` element is in effect from 6.75 to 8.1 hours. When this syntax is used, the last output DR is the *earlier* of the final `spdtimes` time or the final `waypoints` point.

Background

This is a navigational function. It assumes that all latitudes and longitudes are in degrees, all distances are in nautical miles, all times are in hours, and all speeds are in knots, that is, nautical miles per hour.

Dead reckoning is an estimation of position at various times based on courses, speeds, and times elapsed from the last certain position, or fix. In navigational practice, a dead reckoning position, or DR, must be plotted at every course change, every speed change, and at every hour,

on the hour. Navigators also DR at other times that are not relevant to this function.

Often in practice, when two events occur that require DRs within a very short time, only one DR is generated. This function mimics that practice by setting a tolerance of 3 minutes (0.05 hours). No two DRs will fall closer than that.

Refer to "Navigation" in the *Mapping Toolbox Guide* for further information.

Examples

Assume that a navigator gets a fix at noon, 1200Z, which is (10.3ºN, 34.67ºW). He's in a hurry to make a 1330Z rendezvous with another ship at (9.9ºN, 34.5ºW), so he plans on a speed of 25 knots. After the rendezvous, both ships head for (0º, 37ºW). The engineer wants to take an engine off line for maintenance at 1430Z, so at that time, speed must be reduced to 15 knots. At 1530Z, the maintenance will be done. Determine the DR points up to the end of the maintenance.

```
waypoints = [10.1 -34.6; 9.9 -34.5; 0 -37]

waypoints =
   10.1000  -34.6000       % Fix at noon
    9.9000  -34.5000       % Rendezvous point
         0  -37.0000       % Ultimate destination

speed = [25; 15];
spdtimes = [2.5; 3.5];       % Elapsed times after fix
noon = 12;
[drlat,drlong,drtime] = dreckon(waypoints,noon,speed,spdtimes);
[drlat,drlong,drtime]

ans =
    9.8999  -34.4999   12.5354         % Course change at waypoint
    9.7121  -34.5478   13.0000         % On the hour
    9.3080  -34.6508   14.0000         % On the hour
    9.1060  -34.7022   14.5000         % Speed change to 15 kts
    8.9847  -34.7330   15.0000         % On the hour
```

```
    8.8635  -34.7639   15.5000         % Stop at final spdtime, last
          % waypoint has not been reached
```

See Also

legs | navfix | track

Purpose

Heading to correct for wind or current drift

Syntax

```
heading = driftcorr(course,airspeed,windfrom,windspeed)
[heading,groundspeed,windcorrangle] = driftcorr(...)
```

Description

`heading = driftcorr(course,airspeed,windfrom,windspeed)` computes the heading that corrects for drift due to wind (for aircraft) or current (for watercraft). `course` is the desired direction of movement (in degrees), `airspeed` is the speed of the vehicle relative to the moving air or water mass, `windfrom` is the direction facing into the wind or current (in degrees), and `windspeed` is the speed of the wind or current (in the same units as `airspeed`).

`[heading,groundspeed,windcorrangle] = driftcorr(...)` also returns the ground speed and wind correction angle. The wind correction angle is positive to the right, and negative to the left.

Examples

An aircraft cruising at a speed of 160 knots plans to fly to an airport due north of its current position. If the wind is blowing from 310 degrees at 45 knots, what heading should the aircraft fly to remain on course?

```
course=0; airspeed=160;windfrom=310; windspeed = 45;
[heading,groundspeed,windcorrangle] =
driftcorr(course,airspeed,windfrom,windspeed)

heading =

       347.56

groundspeed =

       127.32

windcorrangle =

      -12.442
```

The required heading is 348 degrees, which amounts to a wind correction angle of 12 degrees to the left of course. The headwind component reduces the aircraft's ground speed to 127 knots.

See Also

`driftvel`

driftvel

Purpose

Wind or current from heading, course, and speeds

Syntax

```
[windfrom,windspeed] = driftvel (course,groundspeed,heading,
   airspeed)
```

Description

`[windfrom,windspeed] = driftvel (course,groundspeed,heading,airspeed)` computes the wind (for aircraft) or current (for watercraft) from course, heading, and speeds. `course` and `groundspeed` are the direction and speed of movement relative to the ground (in degrees), `heading` is the direction in which the vehicle is steered, and `airspeed` is the speed of the vehicle relative to the air mass or water. The output `windfrom` is the direction facing into the wind or current (in degrees), and `windspeed` is the speed of the wind or current (in the same units as `airspeed` and `groundspeed`).

Examples

An aircraft is cruising at a true air speed of 160 knots and a heading of 10 degrees. From the Global Positioning System (GPS) receiver, the pilot determines that the aircraft is progressing over the ground at 155 knots in a northerly direction. What is the wind aloft?

```
course = 0; groundspeed = 155; heading = 10; airspeed = 160;
[windfrom,windspeed] =
driftvel(course,groundspeed,heading,airspeed)

windfrom =
       84.717

windspeed =
       27.902
```

The wind is blowing from the right, 085 degrees at 28 knots.

See Also

`driftcorr`

Purpose

Read U.S. Department of Defense Digital Terrain Elevation Data (DTED)

Syntax

```
[Z, refvec] = dted
[Z, refvec] = dted(filename)
[Z, refvec] = dted(filename, samplefactor)
[Z, refvec] = dted(filename, samplefactor, latlim, lonlim)
[Z, refvec] = dted(foldername, samplefactor, latlim, lonlim)
[Z, refvec, UHL, DSI, ACC] = dted(...)
```

Description

`[Z, refvec] = dted` returns all of the elevation data in a DTED file as a regular data grid, `Z`, with elevations in meters. The file is selected interactively. This function reads the DTED elevation files, which generally have filenames ending in `.dtN`, where `N` is 0,1,2,3,... `refvec` is the associated three-element referencing vector that geolocates `Z`.

`[Z, refvec] = dted(filename)` returns all of the elevation data in the specified DTED file. The file must be found on the MATLAB path. If not found, the file may be selected interactively.

`[Z, refvec] = dted(filename, samplefactor)` subsamples data from the specified DTED file. `samplefactor` is a scalar integer. When `samplefactor` is 1 (the default), DTED reads the data at its full resolution. When `samplefactor` is an integer `n` greater than one, every `n`th point is read.

`[Z, refvec] = dted(filename, samplefactor, latlim, lonlim)` reads the data for the part of the DTED file within the latitude and longitude limits. The limits must be two-element vectors in units of degrees.

`[Z, refvec] = dted(foldername, samplefactor, latlim, lonlim)` reads and concatenates data from multiple files within a DTED CD-ROM or folder structure. The `foldername` input is a string with the name of a folder containing the DTED folder. Within the DTED folder are subfolders for each degree of longitude, each of which contain files for each degree of latitude. For DTED CD-ROMs, `foldername` is the device name of the CD-ROM drive.

`[Z, refvec, UHL, DSI, ACC] = dted(...)` returns structures containing the DTED User Header Label (UHL), Data Set Identification (DSI) and Accuracy metadata records.

Background

The U. S. Department of Defense, through the National Geospatial Intelligence Agency, produces several kinds of digital cartographic data. One is digital elevation data, in a series called DTED, for Defense Digital Terrain Elevation Data. The data is available as 1-by-1 degree quadrangles at horizontal resolutions ranging from about 1 kilometer to 1 meter. The lowest resolution data is available to the public. Certain higher resolution data is restricted to the U.S. Department of Defense and its contractors.

DTED Level 0 files have 121-by-121 points. DTED Level 1 files have 1201-by-1201. The edges of adjacent tiles have redundant records. Maps extend a half a cell outside the requested map limits. The 1 kilometer data and some higher-resolution data is available online, as are product specifications and documentation. DTED files are binary. No line ending conversion or byte-swapping is required when downloading a DTED file.

Tips

Latitude-Dependent Sampling

In DTED files north of 50° North and south of 50° South, where the meridians have converged significantly relative to the equator, the longitude sampling interval is reduced to half of the latitude sampling interval. In order to retain square output cells, this function reduces the latitude sampling to match the longitude sampling. For example, it will return a 121-by-121 elevation grid for a DTED file covering from 49 to 50 degrees north, but a 61-by-61 grid for a file covering from 50 to 51 degrees north. When you supply a folder name instead of a file name, and `latlim` spans either 50° North or 50° South, an error results.

Snapping Latitude and Longitude Limits

If you call `dted` specifying arbitrary latitude-longitude limits for a region of interest, the grid and referencing vector returned will not exactly honor the limits you specified unless they fall precisely on grid cell boundaries. Because grid cells are discrete and cannot be arbitrarily

divided, the data grid returned will include all areas between your latitude-longitude limits and the next row or column of cells, potentially in all four directions.

Data Sources and Information

DTED files contain digitial elevation maps covering 1-by-1-degree quadrangles at horizontal resolutions ranging from about 1 kilometer to 1 meter. For details on locating DTED for download over the Internet, see the following documentation at the MathWorks Web site:

```
http://www.mathworks.com/help/map/finding-geospatial-data.html
```

Null Data Values

Some DTED Level 1 and higher data tiles contain null data cells, coded with value `-32767`. When encountered, these null data values are converted to `NaN`.

Nonconforming Data Encoding

DTED files from some sources may depart from the specification by using two's complement encoding for binary elevation files instead of "sign-bit" encoding. This difference affects the decoding of negative values, and incorrect decoding usually leads to nonsensical elevations.

Thus, if the DTED function determines that all the (nonnull) negative values in a file would otherwise be less than -12,000 meters, it issues a warning and assumes two's complement encoding.

Examples

```
[Z,refvec] = dted('n38.dt0');
[Z,refvec,UHL,DSI,ACC] = dted('n38.dt0',1,[38.5 38.8],...
  [-76.8 -76.6]);
[Z,refvec,UHL,DSI,ACC] = dted('f:',1,[38.5 38.8],...
  [-76.8 -76.6]);
```

See Also

`usgsdem` | `gtopo30` | `tbase` | `etopo`

dteds

Purpose

DTED filenames for latitude-longitude quadrangle

Syntax

```
fname = dteds(latlim,lonlim)
fname = dteds(latlim,lonlim,level)
```

Description

`fname = dteds(latlim,lonlim)` returns Level 0 DTED file names (folder and name) required to cover the geographic region specified by `latlim` and `lonlim`.

`fname = dteds(latlim,lonlim,level)` controls the level for which the file names are generated. Valid inputs for the `level` of the DTED files include 0, 1, or 2.

Background

The U. S. Department of Defense produces several kinds of digital cartographic data. One is digital elevation data, in a series called DTED, for Defense Digital Terrain Elevation Data. The data is available as 1-by-1 degree quadrangles at horizontal resolutions ranging from about 1 kilometer to 1 meter. The lowest resolution data is available to the public. Higher resolution data is restricted to the U.S. Department of Defense and its contractors.

Determining the files needed to cover a particular region requires knowledge of the DTED database naming conventions. This function constructs the file names for a given geographic region based on these conventions.

Examples

Which files are needed for Cape Cod?

```
latlim = [ 41.15 42.22]; lonlim = [-70.94 -69.68];
dteds(latlim,lonlim,1)

ans =
    '\DTED\W071\N41.dt1'
    '\DTED\W070\N41.dt1'
    '\DTED\W071\N42.dt1'
    '\DTED\W070\N42.dt1'
```

See Also

`dted`

Purpose

Mean radius of planet Earth

Syntax

```
R = earthRadius
R = earthRadius(lengthUnit)
```

Description

`R = earthRadius` returns the scalar value 6371000, the mean radius of the Earth in meters.

`R = earthRadius(lengthUnit)` returns the mean radius of the Earth using the specified unit of length. The `lengthUnit` input may be any string accepted by the `validateLengthUnit` function.

Examples

```
earthRadius             % Returns 6371000

earthRadius('meters')   % Returns 6371000

earthRadius('km')       % Returns 6371
```

See Also

`unitsratio` | `validateLengthUnit`

eastof

Purpose

Wrap longitudes to values east of specified meridian

Note The `eastof` function is obsolete and will be removed in a future release of Mapping Toolbox software. Replace it with the following calls, which are also more efficient:

```
eastof(lon,meridian,'degrees') ==> meridian+mod(lon-meridian,360)

eastof(lon,meridian,'radians') ==> meridian+mod(lon-meridian,2*pi)
```

Syntax

```
lonWrapped = eastof(lon,meridian)
lonWrapped = eastof(lon,meridian,angleunits)
```

Description

`lonWrapped = eastof(lon,meridian)` wraps angles in `lon` to values in the interval `[meridian meridian+360)`. `lon` is a scalar longitude or vector of longitude values. All inputs and outputs are in degrees.

`lonWrapped = eastof(lon,meridian,angleunits)` specifies the input and output units with the string *`angleunits`*. *`angleunits`* can be either `'degrees'` or `'radians'`. It may be abbreviated and is case-insensitive. If *`angleunits`* is `'radians'`, the input is wrapped to the interval `[meridian meridian+2*pi)`.

Purpose

Flattening of ellipse from eccentricity

Syntax

```
f = ecc2flat(ecc)
f = ecc2flat(ellipsoid)
```

Description

`f = ecc2flat(ecc)` computes the flattening of an ellipse (or ellipsoid of revolution) given its eccentricity `ecc`. Except when the input has 2 columns (or is a row vector), each element is assumed to be an eccentricity and the output `f` has the same size as `ecc`.

`f = ecc2flat(ellipsoid)`, where `ellipsoid` has two columns (or is a row vector), assumes that the eccentricity is in the second column, and a column vector is returned.

See Also

`ecc2n` | `flat2ecc` | `majaxis` | `minaxis`

ecc2n

Purpose

Third flattening of ellipse from eccentricity

Syntax

```
n = ecc2n(ecc)
n = ecc2n(ellipsoid)
```

Description

`n = ecc2n(ecc)` computes the parameter n (the "third flattening") of an ellipse (or ellipsoid of revolution) given its eccentricity `ecc`. n is defined as $(a-b)/(a+b)$, where a is the semimajor axis and b is the semiminor axis. Except when the input has 2 columns (or is a row vector), each element is assumed to be an eccentricity and the output n has the same size as `ecc`.

`n = ecc2n(ellipsoid)`, where `ellipsoid` has two columns (or is a row vector), assumes that the eccentricity is in the second column, and a column vector is returned.

See Also

`ecc2flat` | `majaxis` | `minaxis` | `n2ecc`

Purpose

Geocentric ECEF to local spherical AER

Syntax

```
[az,elev,slantRange] =
ecef2aer(X,Y,Z,lat0,lon0,h0,spheroid)
[ ___ ] = ecef2aer( ___ ,angleUnit)
```

Description

`[az,elev,slantRange] = ecef2aer(X,Y,Z,lat0,lon0,h0,spheroid)` returns coordinates in a local spherical system corresponding to coordinates `X`, `Y`, `Z` in an Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian system. Any of the first six numeric input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = ecef2aer( ___ ,angleUnit)` adds `angleUnit` which specifies the units of inputs `lat0`, `lon0`, and outputs `az`, `elev`.

Input Arguments

X - ECEF x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

Y - ECEF y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

z - ECEF y-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h0 - Ellipsoidal height of local origin

scalar value | vector | matrix | N-D array

Ellipsoidal height of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `h0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in

units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

spheroid - Reference spheroid
scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

angleUnit - Units of angles
`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

az - Azimuth angles
scalar value | vector | matrix | N-D array

Azimuth angles in the local spherical system, returned as a scalar value, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the half-open interval [0 360).

elev - Elevation angles
scalar value | vector | matrix | N-D array

Elevation angles in the local spherical system, returned as a scalar value, vector, matrix, or N-D array. Elevations are with respect to a plane perpendicular to the spheroid surface normal. Units determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the closed interval [-90 90].

slantRange - Distances from local origin
scalar value | vector | matrix | N-D array

Distances from origin in the local spherical system, returned as a scalar value, vector, matrix, or N-D array. The straight-line, 3-D Cartesian distance is computed. Units are determined by the `LengthUnit` property of the `spheroid` input.

See Also

`ecef2enu` | `ecef2ned` | `aer2ecef` | `geodetic2aer`

Purpose

Geocentric ECEF to local Cartesian ENU

Syntax

```
[xEast,yNorth,zUp] = ecef2enu(X,Y,Z,lat0,lon0,h0,spheroid)
[ ___ ] = ecef2enu( ___ ,angleUnit)
```

Description

`[xEast,yNorth,zUp] = ecef2enu(X,Y,Z,lat0,lon0,h0,spheroid)` returns coordinates in a local east-north-up (ENU) Cartesian system corresponding to coordinates `X`, `Y`, `Z` in an Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian system. Any of the first six numeric input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = ecef2enu( ___ ,angleUnit)` adds `angleUnit` which specifies the units of inputs, `lat0`, and `lon0`.

Input Arguments

X - ECEF x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

Y - ECEF y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

Z - ECEF y-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h0 - Ellipsoidal height of local origin

scalar value | vector | matrix | N-D array

Ellipsoidal height of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `h0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in

units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

spheroid - Reference spheroid
scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

angleUnit - Units of angles
`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

xEast - Local ENU x-coordinates
scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the local ENU system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` input.

yNorth - Local ENU y-coordinates
scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the local ENU system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` input.

zUp - Local ENU z-coordinates
scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the local ENU system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` input.

See Also

ecef2ned | ecef2aer | enu2ecef | geodetic2enu

Purpose

Rotate vector from geocentric ECEF to local ENU

Syntax

```
[uEast,vNorth,wUp] = ecef2enuv(U,V,W,lat0,lon0)
[ ___ ] = ecef2enuv( ___ ,angleUnit)
```

Description

`[uEast,vNorth,wUp] = ecef2enuv(U,V,W,lat0,lon0)` returns Cartesian 3-vector components in a local east-north-down (ENU) system corresponding to the 3-vector with components `U`, `V`, `W` in an Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian system. Any of the five numerical input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = ecef2enuv( ___ ,angleUnit)` adds `angleUnit` which specifies the units of inputs `lat0` and `lon0`.

Input Arguments

U - Vector x-components in ECEF system

scalar value | vector | matrix | N-D array

x-components of one or more Cartesian vectors in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

V - Vector y-components in ECEF system

scalar value | vector | matrix | N-D array

y-components of one or more Cartesian vectors in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

W - Vector z-components in ECEF system

scalar value | vector | matrix | N-D array

z-components of one or more Cartesian vectors in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

uEast - Vector x-components in ENU system
scalar value | vector | matrix | N-D array

x-components of one or more Cartesian vectors in the local ENU system, returned as a scalar value, vector, matrix, or N-D array.

vNorth - Vector y-components in ENU system
scalar value | vector | matrix | N-D array

y-components of one or more Cartesian vectors in the local ENU system, returned as a scalar value, vector, matrix, or N-D array.

wUp - Vector z-components in ENU system
scalar value | vector | matrix | N-D array

z-components of one or more Cartesian vectors in the local ENU system, returned as a scalar value, vector, matrix, or N-D array.

See Also

`ecef2enu` | `enu2ecefv` | `ecef2nedv`

ecef2geodetic

Purpose

Convert geocentric (ECEF) to geodetic coordinates

Syntax

```
[phi,lambda,h] = ecef2geodetic(x,y,z,ellipsoid)
```

Description

`[phi,lambda,h] = ecef2geodetic(x,y,z,ellipsoid)` converts geocentric Cartesian coordinates, stored in the coordinate arrays `x`, `y`, `z`, to geodetic coordinates `phi` (geodetic latitude in radians), `lambda` (geodetic longitude in radians), and `h` (height above the ellipsoid). `ellipsoid` is a `referenceEllipsoid` (`oblateSpheroid`) object, a `referenceSphere` object, or a vector of the form `[semimajor axis, eccentricity]`. Arrays `x`, `y`, `z`, and `h` must use the same units as the semimajor axis. `x`, `y`, `z`, `phi`, `lambda`, and `h` must have the same shape.

Definitions

For a definition of the geocentric system, also known as Earth-Centered, Earth-Fixed (ECEF), see the help for `geodetic2ecef`.

See Also

`ecef2lv` | `geodetic2ecef` | `lv2ecef`

Purpose

Convert geocentric (ECEF) to local vertical coordinates

Note `ecef2lv` will be removed in a future release. Use `ecef2enu` instead. In `ecef2enu`, the latitude and longitude of the local origin are in degrees by default, so the optional `angleUnit` input should be included, with the value `'radians'`.

Syntax

```
[xl,yl,zl] = ecef2lv(x,y,z,phi0,lambda0,h0,ellipsoid)
```

Description

`[xl,yl,zl] = ecef2lv(x,y,z,phi0,lambda0,h0,ellipsoid)` converts geocentric point locations specified by the coordinate arrays `x`, `y`, and `z` to the local vertical coordinate system, with its origin at geodetic latitude `phi0`, longitude `lambda0`, and ellipsoidal height `h0`. The arrays `x`, `y`, and `z` may be of any shape, as long as they all match in size. `phi0`, `lambda0`, and `h0` must be scalars. `ellipsoid` is a `referenceEllipsoid` (`oblateSpheroid`) object, a `referenceSphere` object, or a vector of the form `[semimajor axis, eccentricity]`). `x`, `y`, `z`, and `h0` must have the same length units as the semimajor axis. `phi0` and `lambda0` must be in radians. The output coordinate arrays, `xl`, `yl`, and `zl` are the local vertical coordinates of the input points. They have the same size as `x`, `y`, and `z` and have the same length units as the semimajor axis.

In the local vertical Cartesian system defined by `phi0`, `lambda0`, `h0`, and `ellipsoid`, the `xl` axis is parallel to the plane tangent to the ellipsoid at (`phi0`,`lambda0`) and points due east. The `yl` axis is parallel to the same plane and points due north. The `zl` axis is normal to the ellipsoid at (`phi0`,`lambda0`) and points outward into space. The local vertical system is sometimes referred to as east-north-up or ENU.

Definitions

For a definition of the *geocentric system*, also known as Earth-Centered, Earth-Fixed (ECEF), see the help for `geodetic2ecef`.

See Also

`ecef2enu`

ecef2ned

Purpose

Geocentric ECEF to local Cartesian NED

Syntax

```
[xNorth,yEast,zDown] =
ecef2ned(X,Y,Z,lat0,lon0,h0,spheroid)
[ ___ ] = ecef2ned( ___ ,angleUnit)
```

Description

`[xNorth,yEast,zDown] = ecef2ned(X,Y,Z,lat0,lon0,h0,spheroid)` returns coordinates in a local north-east-down (NED) Cartesian system corresponding to coordinates `X`, `Y`, `Z` in an Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian system. Any of the first six numeric input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = ecef2ned( ___ ,angleUnit)` adds `angleUnit` which specifies the units of inputs `lat0`, and `lon0`.

Input Arguments

X - ECEF x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

Y - ECEF y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

z - ECEF y-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types

single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types

single | double

h0 - Ellipsoidal height of local origin

scalar value | vector | matrix | N-D array

Ellipsoidal height of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `h0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in

units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

spheroid - Reference spheroid
scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

angleUnit - Units of angles
`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

xNorth - Local NED x-coordinates
scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the local NED system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` input.

yEast - Local NED y-coordinates
scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the local NED system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` input.

zDown - Local NED z-coordinates
scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the local NED system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` input.

See Also

ecef2enu | ecef2aer | ned2ecef | geodetic2ned

ecef2nedv

Purpose

Rotate vector from geocentric ECEF to local NED

Syntax

```
[uNorth,vEast,wDown] = ecef2nedv(U,V,W,lat0,lon0)
[ ___ ] = ecef2nedv( ___ ,angleUnit)
```

Description

`[uNorth,vEast,wDown] = ecef2nedv(U,V,W,lat0,lon0)` returns Cartesian 3-vector components in a local north-east-down (NED) system corresponding to the 3-vector with components U, V, W in an Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian system. Any of the five numerical input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = ecef2nedv( ___ ,angleUnit)` adds `angleUnit` which specifies the units of inputs `lat0` and `lon0`.

Input Arguments

U - Vector x-components in ECEF system

scalar value | vector | matrix | N-D array

x-components of one or more Cartesian vectors in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

V - Vector y-components in ECEF system

scalar value | vector | matrix | N-D array

y-components of one or more Cartesian vectors in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

W - Vector z-components in ECEF system

scalar value | vector | matrix | N-D array

z-components of one or more Cartesian vectors in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

uNorth - Vector x-components in NED system
scalar value | vector | matrix | N-D array

x-components of one or more Cartesian vectors in the local NED system, returned as a scalar value, vector, matrix, or N-D array.

vEast - Vector y-components in NED system
scalar value | vector | matrix | N-D array

y-components of one or more Cartesian vectors in the local NED system, returned as a scalar value, vector, matrix, or N-D array.

wDown - Vector z-components in NED system
scalar value | vector | matrix | N-D array

z-components of one or more Cartesian vectors in the local NED system, returned as a scalar value, vector, matrix, or N-D array.

See Also

`ecef2enuv` | `ned2ecefv` | `ecef2ned`

Purpose

Read 15-minute gridded geoid heights from EGM96

Syntax

```
[N, refvec] = egm96geoid(samplefactor)
[N, refvec] = egm96geoid(samplefactor,latlim,lonlim)
```

Description

`[N, refvec] = egm96geoid(samplefactor)` imports global geoid height in meters from the EGM96 geoid model. The data set is gridded at 15-minute intervals, but may be down-sampled as specified by the positive integer `samplefactor`. The result is returned in the regular data grid `N` along with referencing vector `refvec`. At full resolution (a `samplefactor` of 1), `N` will be 721-by-1441.

The gridded EGM96 data set must be on your path in a file named `'WW15MGH.GRD'`.

`[N, refvec] = egm96geoid(samplefactor,latlim,lonlim)` imports data for the part of the world within the specified latitude and longitude limits. The limits must be two-element vectors in units of degrees. Longitude limits can be defined in the range [-180 180] or [0 360]. For example, `lonlim = [170 190]` returns data centered on the dateline, while `lonlim = [-10 10]` returns data centered on the prime meridian.

Background

Although the Earth is round, it is not exactly a sphere. The shape of the Earth is usually defined by the geoid, which is defined as a gravitational equipotential surface, but can be conceptualized as the shape the ocean surface would take in the absence of waves, weather, and land. For cartographic purposes it is generally sufficient to treat the Earth as a sphere or ellipsoid of revolution. For other applications, a more detailed model of the geoid such as EGM 96 may be required. EGM 96 is a spherical harmonic model of the geoid complete to degree and order 360. This function reads from a file of gridded geoid heights derived from the EGM 96 harmonic coefficients.

Examples

Read the EGM 96 geoid grid for the world, taking every 10th point.

```
[N,refvec] = egm96geoid(10);
```

Read a subset of the geoid grid at full resolution and interpolate to find the geoid height at a point between grid points.

```
[N,refvec] = egm96geoid(1,[-10 -12],[129 132]);
n = ltln2val(N,refvec,-11.1,130.22,'bicubic')

n =
 52.7151
```

Tips

This function reads the 15-minute EGM96 grid file `WW15MGH.GRD`. The grid is available as either a DOS self-extracting compressed file or a UNIX compressed file. Do not modify the file once it has been extracted.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: http://www.mathworks.com/help/map/finding-geospatial-data.html

---

Maps will extend a half a cell outside the requested map limits.

There are 721 rows and 1441 columns of values in the grid at full resolution. The low resolution data in `GEOID.MAT` is derived from the EGM 96 grid.

See Also

`ltln2val`

Purpose

Local vertical elevation angle, range, and azimuth

Note `elevation` will be removed in a future release. Use `geodetic2aer` instead.

The reference point comes second in the `geodetic2aer` argument list, and the outputs are ordered differently. The replacement pattern is:

```
[azimuthangle, elevationangle, slantrange] =
geodetic2aer(lat2, lon2, alt2, lat1, lon1, alt1,
spheroid, ...)
```

Unlike `elevation`, `geodetic2aer` requires a spheroid input, and it must be must be an `oblateSpheroid`, `referenceEllipsoid`, or `referenceSphere` object, not a 2-by-1 ellipsoid vector.

You can use the following steps to convert an ellipsoid vector, `ellipsoid`, to an `oblateSpheroid` object, `spheroid`:

- `spheroid = oblateSpheroid;`
- `spheroid.SemimajorAxis = ellipsoid(1);`
- `spheroid.Eccentricity = ellipsoid(2);`

When elevation is called with only 6 inputs, the GRS 80 reference ellipsoid, in meters, is used by default. To replace this usage, use `referenceEllipsoid('GRS80','meters')` as the spheroid input for `geodetic2aer`.

If an `angleunits` input is included, it must follow the `spheroid` input in the call to `geodetic2aer`, rather than preceding it.

`elevation` can be called with a `lengthunits` string, but `geodetic2aer` has no such input. Set the `LengthUnit` property of the input spheroid to the desired value instead. In this case a `referenceEllipsoid` or `referenceSphere` object must be used (not an `oblateSpheroid` object).

---

elevation

Syntax

```
[elevationangle,slantrange,azimuthangle] = ...
  elevation(lat1,lon1,alt1,lat2,lon2,alt2)
[...] = elevation(lat1,lon1,alt1,lat2,lon2,alt2,...
  angleunits)
[...] = elevation(lat1,lon1,alt1,lat2,lon2,alt2,...
  angleunits,distanceunits)
[...] = elevation(lat1,lon1,alt1,lat2,lon2,alt2,...
  angleunits,ellipsoid)
```

Description

`[elevationangle,slantrange,azimuthangle] = ...
  elevation(lat1,lon1,alt1,lat2,lon2,alt2)` computes the elevation angle, slant range, and azimuth angle of point 2 (with geodetic coordinates `lat2`, `lon2`, and `alt2`) as viewed from point 1 (with geodetic coordinates `lat1`, `lon1`, and `alt1`). The coordinates `alt1` and `alt2` are ellipsoidal heights. The elevation angle is the angle of the line of sight above the local horizontal at point 1. The slant range is the three-dimensional Cartesian distance between point 1 and point 2. The azimuth is the angle from north to the projection of the line of sight on the local horizontal. Angles are in units of degrees; altitudes and distances are in meters. The figure of the earth is the default ellipsoid (GRS 80).

Inputs can be vectors of points, or arrays of any shape, but must match in size, with the following exception: Elevation, range, and azimuth from a single point to a set of points can be computed very efficiently by providing scalar coordinate inputs for point 1 and vectors or arrays for point 2.

`[...] = elevation(lat1,lon1,alt1,lat2,lon2,alt2,...
  angleunits)` uses the string *`angleunits`* to specify the units of the input and output angles. If the string *`angleunits`* is omitted, `'degrees'` is assumed.

`[...] = elevation(lat1,lon1,alt1,lat2,lon2,alt2,...
  angleunits,distanceunits)` uses the string *`distanceunits`* to specify the altitude and slant-range units. If the string *`distanceunits`* is omitted, `'meters'` is assumed. Any units string recognized by `unitsratio` may be used.

`[...] = elevation(lat1,lon1,alt1,lat2,lon2,alt2,...`
`  angleunits,ellipsoid)` uses `ellipsoid` to specify the ellipsoid. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. If `ellipsoid` is supplied, the altitudes must be in the same units as the semimajor axis, and the slant range will be returned in these units. If `ellipsoid` is omitted, the default is a unit sphere. Distances are in meters unless otherwise specified.

Note The line-of-sight azimuth angles returned by `elevation` will generally differ slightly from the corresponding outputs of `azimuth` and `distance`, except for great circle azimuths on a spherical earth.

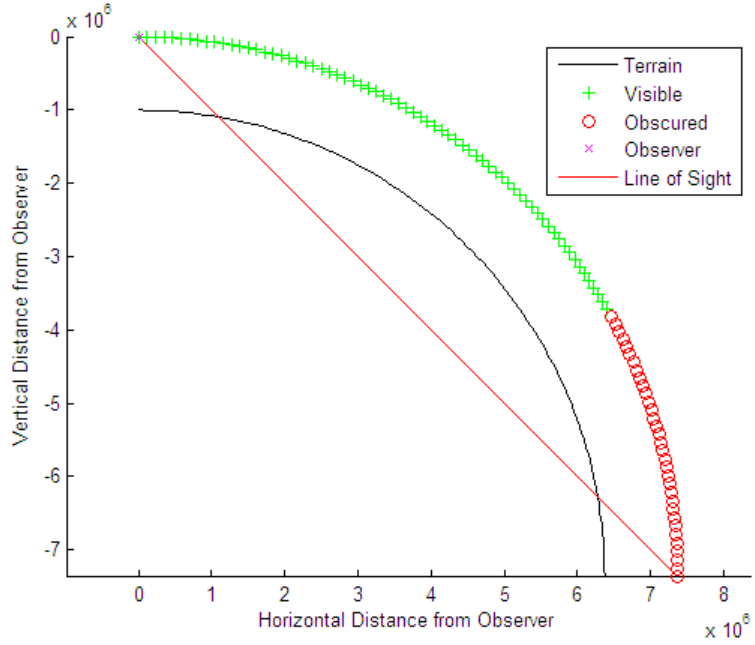
Examples

Find the elevation angle of a point 90 degrees from an observer assuming that the observer and the target are both 1000 km above the Earth.

```
lat1 = 0; lon1 = 0; alt1 = 1000*1000;
lat2 = 0; lon2 = 90; alt2 = 1000*1000;
elevang = elevation(lat1,lon1,alt1,lat2,lon2,alt2)

elevang =
   -45
```

Visually check the result using the `los2` line of sight function. Construct a data grid of zeros to represent the Earth's surface. The `los2` function with no output arguments creates a figure displaying the geometry.

```
Z = zeros(180,360);
refvec = [1 90 -180];
los2(Z,refvec,lat1,lon1,lat2,lon2,alt1,alt1);
```



See Also `oblateSpheroid |`

Purpose

Geographic ellipse from center, semimajor axes, eccentricity, and azimuth

Syntax

```
[lat,lon] = ellipse1(lat0,lon0,ellipse)
[lat,lon] = ellipse1(lat0,lon0,ellipse,offset)
[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az)
[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az,ellipsoid)
[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,units)

[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az,

[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az,ellipsoid,
[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az,ellipsoid,
   units,npts)
[lat,lon] = ellipse1(track,...)
mat = ellipse1(...)
```

Description

`[lat,lon] = ellipse1(lat0,lon0,ellipse)` computes ellipse(s) with center(s) at `lat0,lon0`. The ellipse is defined by the third input, which is of the form `[semimajor axis,eccentricity]`, where the eccentricity input can be a two-element row vector or a two-column matrix. The ellipse input must have the same number of rows as the input scalar or column vectors `lat0` and `lon0`. The input semimajor axis is in degrees of arc length on a sphere. All ellipses are oriented so that their major axes run north-south.

`[lat,lon] = ellipse1(lat0,lon0,ellipse,offset)` computes the ellipse(s) where the major axis is rotated from due north by an azimuth offset. The `offset` angle is measured clockwise from due north. If `offset = []`, then no offset is assumed.

`[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az)` uses the input `az` to define the ellipse arcs computed. The arc azimuths are measured clockwise from due north. If `az` is a column vector, then the arc length is computed from due north. If `az` is a two-column matrix, then the ellipse arcs are computed starting at the azimuth in the first column and ending at the azimuth in the second column. If `az = []`, then a complete ellipse is computed.

`[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az,ellipsoid)` computes the ellipse on the ellipsoid defined by the input `ellipsoid`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. If omitted, the unit sphere, is assumed. When an ellipsoid is supplied, the input semimajor axis must be in the same units as the ellipsoid semimajor axes. In this calling form, the units of the ellipse semimajor axis are not assumed to be in degrees.

`[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,`*`units`*`)`, `[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az,`*`units`*`)`, and `[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az,ellipsoid,`*`units`*`)` are all valid calling forms, which use the input *`units`* to define the angle units of the inputs and outputs. If the *`units`* string is omitted, `'degrees'` is assumed.

`[lat,lon] = ellipse1(lat0,lon0,ellipse,offset,az,ellipsoid,`*`units`*`,npts)` uses the scalar `npts` to determine the number of points per ellipse computed. If `npts` is omitted, 100 points are used.

`[lat,lon] = ellipse1(`*`track`*`,...)` uses the *`track`* string to define either great circle or rhumb line distances from the ellipse center. If *`track`* = `'gc'`, then great circle distances are computed (the default). If *`track`* = `'rh'`, then rhumb line distances are computed.

`mat = ellipse1(...)` returns a single output argument where `mat = [lat lon]`. This is useful if only one ellipse is computed.

You can define multiple ellipses with a common center by providing scalar `lat0` and `lon0` inputs and a two-column `ellipse` matrix.

Examples

Create and plot the small ellipse centered at (0^o,0^o), with a semimajor axis of 10^o and a semiminor axis of 5^o.

```
axesm mercator
ecc = axes2ecc(10,5);
plotm(0,0,'r+')
```

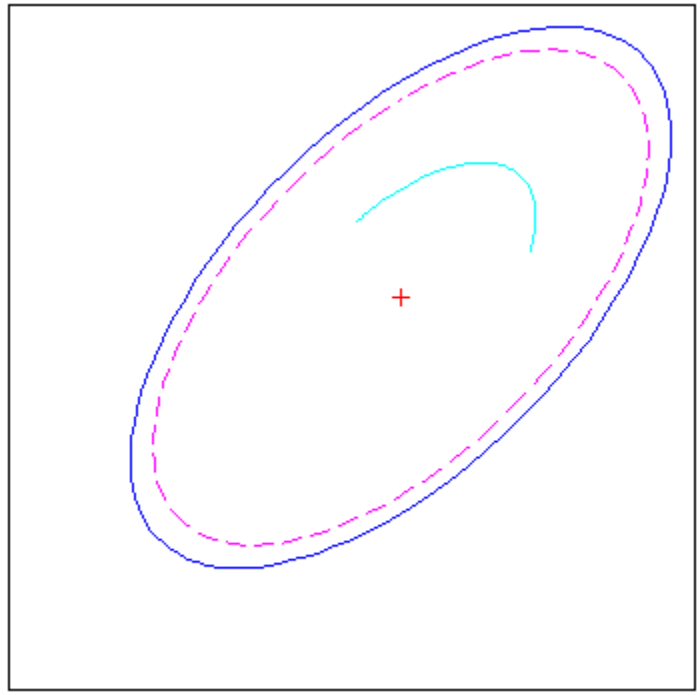
```
[elat,elon] = ellipse1(0,0,[10 ecc],45);
plotm(elat,elon)
```

If the desired radius is known in some nonangular distance unit, use the radius returned by the `earthRadius` function as the ellipsoid input to set the range units. (Use an empty azimuth entry to specify a full ellipse.)

```
[elat,elon] = ellipse1(0,0,[550 ecc],45,[],earthRadius('nm'));
plotm(elat,elon,'m--')
```

For just an arc of the ellipse, enter an azimuth range:

```
[elat,elon] = ellipse1(0,0,[5 ecc],45,[-30 70]);
plotm(elat,elon,'c-')
```



See Also

axes2ecc | scircle1 | track1

Purpose

Fill in regular data grid from seed values and locations

Syntax

```
newgrid = encodem(Z,seedmat)
newgrid = encodem(Z,seedmat,stopvals)
```

Description

`newgrid = encodem(Z,seedmat)` fills in regions of the input data grid, `Z`, with desired new values. The boundary consists of the edges of the matrix and any entries with the value `1`. The *seeds*, or starting points, and the values associated with them, are specified by the three-column matrix `seedmat`, the rows of which have the form `[row column value]`.

`newgrid = encodem(Z,seedmat,stopvals)` allows you to specify a vector, `stopvals`, of stopping values. Any value that is an element of `stopvals` will act as a boundary.

This function *fills in* regions of data grids with desired values. If a *boundary* exists, the new value replaces all entries in all four directions until the boundary is reached. The boundary is made up of selected stopping values and the edges of the matrix. The new value tries to flood the region exhaustively, stopping only when no new spaces can be reached by moving up, down, left, or right without hitting a stopping value.

Examples

For this imaginary map, fill in the upper right region with 7s and the lower left region with 3s:

```
Z = eye(4)

Z =
     1     0     0     0
     0     1     0     0
     0     0     1     0
     0     0     0     1

newgrid = encodem(Z,[4,1,3; 1,4,7])

newgrid =
     1     7     7     7
```

```
     3     1     7     7
     3     3     1     7
     3     3     3     1
```

See Also

`getseeds | imbedm`

Purpose

Local Cartesian ENU to local spherical AER

Syntax

```
[az,elev,slantRange] = enu2aer(xEast,yNorth,zUp)
[ ___ ] = enu2aer( ___ ,angleUnit)
```

Description

`[az,elev,slantRange] = enu2aer(xEast,yNorth,zUp)` returns coordinates in a local spherical system corresponding to coordinates `xEast`, `yNorth`, `zUp` in a local east-north-up (ENU) Cartesian system having the same local origin. Any of the three numerical input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = enu2aer( ___ ,angleUnit)` adds `angleUnit` which specifies the units outputs `az`, `elev`.

Input Arguments

xEast - Local ENU x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the the local ENU system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

yNorth - Local ENU y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the the local ENU system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

zUp - Local ENU z-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the the local ENU system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as ‘degrees’ (default), or ’radians’.

Data Types
char

Output Arguments

az - Azimuth angles

scalar value | vector | matrix | N-D array

Azimuth angles in the local spherical system, returned as a scalar value, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the half-open interval [0 360).

elev - Elevation angles

scalar value | vector | matrix | N-D array

Elevation angles in the local spherical system, returned as a scalar value, vector, matrix, or N-D array. Elevations are with respect to a plane perpendicular to the spheroid surface normal. Units determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the closed interval [-90 90].

slantRange - Distances from local origin

scalar value | vector | matrix | N-D array

Distances from origin in the local spherical system, returned as a scalar, vector, matrix, or N-D array. The straight-line, 3-D Cartesian distance is computed.

See Also

`aer2enu` | `ned2aer`

Purpose

Local Cartesian ENU to geocentric ECEF

Syntax

```
[X,Y,Z] = enu2ecef(xEast,yNorth,zUp,lat0,lon0,h0,spheroid)
[ ___ ] = enu2ecef( ___ ,angleUnits)
```

Description

`[X,Y,Z] = enu2ecef(xEast,yNorth,zUp,lat0,lon0,h0,spheroid)` returns Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian coordinates corresponding to coordinates `xEast`, `yNorth`, `zUp` in a local east-north-up (ENU) Cartesian system.Any of the first six numeric input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = enu2ecef( ___ ,angleUnits)` adds `angleUnit` which specifies the units of inputs `lat0` and `lon0`.

Input Arguments

xEast - Local ENU x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the the local ENU system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

yNorth - Local ENU y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the the local ENU system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

zUp - Local ENU z-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the the local ENU system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h0 - Ellipsoidal height of local origin

scalar value | vector | matrix | N-D array

Ellipsoidal height of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `h0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in

units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

X - ECEF x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

Y - ECEF y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

Z - ECEF y-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

See Also

ned2ecef | aer2ecef | ecef2enu | enu2geodetic

Purpose

Rotate vector from local ENU to geocentric ECEF

Syntax

```
[U,V,W] = enu2ecefv(uEast,vNorth,wUp,lat0,lon0)
[ ___ ] = enu2ecefv( ___ ,angleUnit)
```

Description

`[U,V,W] = enu2ecefv(uEast,vNorth,wUp,lat0,lon0)` returns coordinates in a local spherical system corresponding to coordinates `xNorth`, `yEast`, `zDown` in a local north-east-down (NED) Cartesian system having the same local origin. Any of the three numerical input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = enu2ecefv( ___ ,angleUnit)` adds `angleUnit` which specifies the units of inputs `lat0` and `lon0`.

Input Arguments

uEast - Vector x-components in ENU system

scalar value | vector | matrix | N-D array

x-components of one or more Cartesian vectors in the local ENU system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

vNorth - Vector y-components in ENU system

scalar value | vector | matrix | N-D array

y-components of one or more Cartesian vectors in the local ENU system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

wUp - Vector z-components in ENU system

scalar value | vector | matrix | N-D array

z-components of one or more Cartesian vectors in the local ENU system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

U - Vector x-components in ECEF system

scalar value | vector | matrix | N-D array

x-components of one or more Cartesian vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array.

V - Vector y-components in ECEF system

scalar value | vector | matrix | N-D array

y-components of one or more Cartesian vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array.

W - Vector z-components in ECEF system

scalar value | vector | matrix | N-D array

z-components of one or more Cartesian vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array.

See Also

`ecef2enu` | `enu2ecef` | `ned2ecefv`

enu2geodetic

Purpose

Local Cartesian ENU to geodetic

Syntax

```
[lat,lon,h] = enu2geodetic(xEast,yNorth,zUp,lat0,lon0,h0,
   spheroid)
[ ___ ] = enu2geodetic( ___ ,angleUnits)
```

Description

`[lat,lon,h] = enu2geodetic(xEast,yNorth,zUp,lat0,lon0,h0,spheroid))` returns geodetic coordinates corresponding to coordinates `xEast`, `yNorth`, `zUp` in a local east-north-up (ENU) Cartesian system. Any of the first six numeric input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = enu2geodetic( ___ ,angleUnits)` adds `angleUnit` which specifies the units of inputs `lat0`, `lon0`, and outputs `lat`, `lon`.

Input Arguments

xEast - Local ENU x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the the local ENU system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

yNorth - Local ENU y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the the local ENU system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

zUp - Local ENU z-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the the local ENU system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h0 - Ellipsoidal height of local origin

scalar value | vector | matrix | N-D array

Ellipsoidal height of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `h0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in

units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

spheroid - Reference spheroid
scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

angleUnit - Units of angles
`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

lat - Geodetic latitudes
scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the closed interval [-90 90].

lon - Longitudes
scalar value | vector | matrix | N-D array

Longitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the interval [-180 180].

h - Ellipsoidal heights
scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object

See Also

`aer2geodetic` | `enu2ecef` | `geodetic2enu` | `ned2geodetic`

epsm

Purpose

Accuracy in angle units for certain map computations

Syntax

```
epsm
epsm(units)
```

Description

`epsm` is the limit of map angular precision. It is useful in avoiding trigonometric singularities, among other things.

`epsm(units)` returns the same angle in units corresponding to any valid angle units string. The default is `'degrees'`.

Examples

The value of `epsm` is 10^{-6} degrees. To put this in perspective, in terms of an angular arc length, the distance is

```
epsmkm = deg2km(epsm)

epsmkm =
   1.1119e-04      % kilometers
```

This is about 11 centimeters, a very small distance on a global scale.

See Also

`roundn`

Purpose

Convert from equal area to Greenwich coordinates

Syntax

```
[lat,lon] = eqa2grn(x,y)
[lat,lon] = eqa2grn(x,y,origin)
[lat,lon] = eqa2grn(x,y,origin,ellipsoid)
[lat,lon] = eqa2grn(x,y,origin,units)
mat = eqa2grn(x,y,origin...)
```

Description

`[lat,lon] = eqa2grn(x,y)` converts the equal-area coordinate points `x` and `y` to the Greenwich (standard geographic) coordinates `lat` and `lon`.

`[lat,lon] = eqa2grn(x,y,origin)` specifies the location in the Greenwich system of the *x-y* origin (0,0). The two-element vector `origin` must be of the form `[latitude longitude]`. The default places the origin at the Greenwich coordinates (0º,0º).

`[lat,lon] = eqa2grn(x,y,origin,ellipsoid)` specifies the ellipsoidal model of the figure of the Earth using `ellipsoid`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The `ellipsoid` is a unit sphere by default.

`[lat,lon] = eqa2grn(x,y,origin,units)` specifies the units for the outputs, where *`units`* is any valid angle units string. The default value is `'degrees'`.

`mat = eqa2grn(x,y,origin...)` packs the outputs into a single variable.

This function converts data from equal-area *x-y* coordinates to geographic (latitude-longitude) coordinates. The opposite conversion can be performed with `grn2eqa`.

Examples

```
[lat,lon] = eqa2grn(.5,.5)

lat =
   30.0000
lon =
```

```
    28.6479
```

See Also grn2eqa | hista

Purpose

Read gridded global relief data (ETOPO products)

Syntax

```
[Z, refvec] = etopo
[Z, refvec] = etopo(samplefactor)
[Z, refvec] = etopo(samplefactor, latlim, lonlim)
[Z, refvec] = etopo(folder, ...)
[Z, refvec] = etopo(filename, ...)
[Z, refvec] = etopo({'etopo5.northern.bat',
   'etopo5.southern.bat'}, ...)
```

Description

`[Z, refvec] = etopo` reads the ETOPO data for the entire world from the ETOPO data in the current folder. The `etopo` function searches the current folder first for ETOPO1c binary data, then ETOPO2V2c binary data, then ETOPO2 (2001) binary data, then ETOPO5 binary data, and finally ETOPO5 ASCII data. Once the function finds a case-insensitive file name match, it reads the data. See the table Supported ETOPO Data File Names on page 3-260 for a list of possible file names. The `etopo` function returns the data grid, `Z`, as an array of elevations. Data values, in whole meters, represent the elevation of the center of each cell. `refvec`, the associated three-element referencing vector, geolocates `Z`.

`[Z, refvec] = etopo(samplefactor)` reads the data for the entire world, downsampling the data by `samplefactor`. The scalar integer `samplefactor` when equal to 1 gives the data at its full resolution (10800 by 21600 values for ETOPO1 data, 5400 by 10800 values for ETOPO2 data, and 2160 by 4320 values for ETOPO5 data). When `samplefactor` is an integer n greater than one, the `etopo` function returns every n^{th} point. If you omit `samplefactor` or leave it empty, it defaults to 1. (If the `etopo` function reads an older, ASCII ETOPO5 data set, then `samplefactor` must divide evenly into the number of rows and columns of the data file.)

`[Z, refvec] = etopo(samplefactor, latlim, lonlim)` reads the data for the part of the world within the specified latitude and longitude limits. Specify the limits of the desired data as two-element vectors of latitude, `latlim`, and longitude, `lonlim`, in degrees. Specify the elements of `latlim` and `lonlim` in ascending order. Specify `lonlim` in

the range `[0 360]` for ETOPO5 data and `[-180 180]` for ETOPO2 and ETOPO1 data. If `latlim` is empty, the latitude limits are [-90 90]. If `lonlim` is empty, the file type determines the longitude limits.

`[Z, refvec] = etopo(folder, ...)` allows you to use the variable `folder` to specify the path for the ETOPO data file. Otherwise, the `etopo` function searches the current folder for the data.

`[Z, refvec] = etopo(filename, ...)` reads the ETOPO data from `filename`. The variable `filename`, a case-insensitive string, specifies the name of the ETOPO file, as referenced in the ETOPO data file names table. Include the folder name in `filename` or place the file in the current folder or in a folder on the MATLAB path.

`[Z, refvec] = etopo({'etopo5.northern.bat', 'etopo5.southern.bat'}, ...)` reads the ETOPO data from the specified case-insensitive ETOPO5 ASCII data files. Place the files in the current folder or in a folder on the MATLAB path.

Tips

Supported ETOPO Data File Names

Format	Filenames
ETOPO1c (cell)	• `etopo1_ice_c.flt` • `etopo1_bed_c.flt` • `etopo1_ice_c_f4.flt` • `etopo1_bed_c_f4.flt` • `etopo1_ice_c_i2.bin` • `etopo1_bed_c_i2.bin`
ETOPO2V2c (cell)	• `ETOPO2V2c_i2_MSB.bin` • `ETOPO2V2c_i2_LSB.bin` • `ETOPO2V2c_f4_MSB.flt` • `ETOPO2V2c_f4_LSB.flt` • `ETOPO2V2c.hdf`

Supported ETOPO Data File Names (Continued)

Format	Filenames
ETOPO2 (2001)	• `ETOPO2.dos.bin` • `ETOPO2.raw.bin`
ETOPO5 (binary)	• `ETOPO5.DOS` • `ETOPO5.DAT`
ETOPO5 (ASCII)	• `etopo5.northern.bat` • `etopo5.southern.bat`

- For details on locating ETOPO data for download over the Internet, see the following documentation at the MathWorks Web site: http://www.mathworks.com/help/map/finding-geospatial-data.html .

Definitions

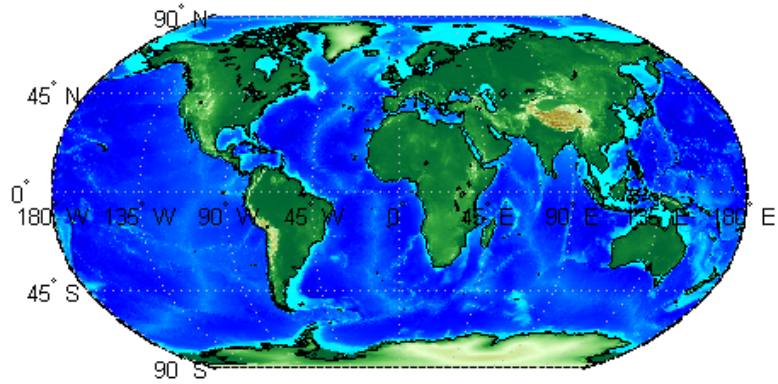
According to the National Geophysical Data Center (NGDC) Web site, ETOPO models combine regional and global land topography and ocean bathymetry data from many data sources. ETOPO1, the most recent model, has an Ice Surface version showing the top of the Antarctic and Greenland ice sheets and a Bedrock version showing the bedrock below the ice sheets. For detailed information about the data sources used to create the ETOPO1 model, see the NGDC Web site. NGDC lists the ETOPO2 and ETOPO5 models as deprecated but still available.

Model	Cell Size	Date Available
ETOPO1	1-arc-minute	March 2009
ETOPO2v2	2-minute	2006
ETOPO2	2-minute	2001
ETOPO5	5-minute	1988

Examples

Read and display ETOPO2V2c data from the file `'ETOPO2V2c_i2_LSB.bin'` downsampled to half-degree cell size and display the boundary of the land areas.

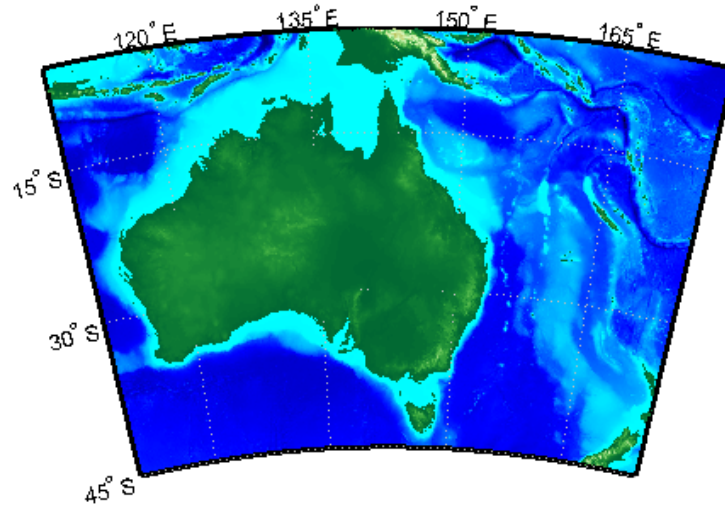
```
samplefactor = 15;
[Z, refvec] = etopo('ETOPO2V2c_i2_LSB.bin', samplefactor);
figure
worldmap world
geoshow(Z, refvec, 'DisplayType', 'texturemap');
demcmap(Z, 256);
geoshow('landareas.shp', 'FaceColor', 'none', ...
   'EdgeColor', 'black');
```



Read and display ETOPO1 data for a region around Australia.

```
figure
worldmap australia
mstruct = gcm;
latlim = mstruct.maplatlimit;
lonlim = mstruct.maplonlimit;
[Z, refvec] = etopo('etopo1_ice_c.flt', 1, latlim, lonlim);
```

```
geoshow(Z, refvec, 'DisplayType', 'surface');
demcmap(Z, 256);
```



References

[1] "2-minute Gridded Global Relief Data (ETOPO2v2)," U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Geophysical Data Center, 2006.

[2] Amante, C. and B. W. Eakins, "ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis," *NOAA Technical Memorandum NESDIS NGDC-24*, March 2009.

[3] "Digital Relief of the Surface of the Earth," *Data Announcement 88-MGG-02*, NOAA, National Geophysical Data Center, Boulder, Colorado, 1988.

[4] "ETOPO2v2 Global Gridded 2-minute Database," National Geophysical Data Center, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce.

See Also

gtopo30 | tbase | usgsdem

Purpose

Read global 5-min digital terrain data

Syntax

Note `etopo5` will be removed in a future version; use `etopo` instead.

```
[Z, refvec] = etopo5
[Z, refvec] = etopo5(samplefactor)
[[Z, refvec] = etopo5(samplefactor, latlim, lonlim)
[Z, refvec] = etopo5(folder, ...)
[Z, refvec] = etopo5(file, ...)
```

Description

`[Z, refvec] = etopo5` reads the topography data for the entire world for the data in the current folder. The current folder is searched first for `ETOPO2` binary data, followed by ETOPO5 binary data, followed by ETOPO5 ASCII data from the file names `etopo5.northern.bat` and `etopo5.southern.bat`. Once a match is found the data is read. The data grid, `Z`, is returned as an array of elevations. Data values are in whole meters, representing the elevation of the center of each cell. `refvec` is the associated three-element referencing vector that geolocates `Z`.

`[Z, refvec] = etopo5(samplefactor)` reads the data for the entire world, downsampling the data by `samplefactor`. `samplefactor` is a scalar integer, which when equal to 1 gives the data at its full resolution (1080 by 4320 values). When `samplefactor` is an integer n greater than one, every n^{th} point is returned. `samplefactor` must divide evenly into the number of rows and columns of the data file. If `samplefactor` is omitted or empty, it defaults to 1.

`[[Z, refvec] = etopo5(samplefactor, latlim, lonlim)` reads the data for the part of the world within the specified latitude and longitude limits. The limits of the desired data are specified as two-element vectors of latitude, `latlim`, and longitude, `lonlim`, in degrees. The elements of `latlim` and `lonlim` must be in ascending order. If `latlim` is empty the latitude limits are `[-90 90]`. `lonlim` must be specified in the range [0 360]. If `lonlim` is empty, the longitude limits are `[0 360]`.

`[Z, refvec] = etopo5(folder, ...)` allows the path for the data file to be specified by `folder` rather than the current folder.

`[Z, refvec] = etopo5(file, ...)` reads the data from `file`, where `file` is a string or a cell array of strings containing the name or names of the data files.

ETOPO5 is being superseded by ETOPO2 and the TerrainBase digital terrain model. See the `tbase` external interface function for more information.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web Site: http://www.mathworks.com/help/map/finding-geospatial-data.html

---

Examples

Example 1

Read every tenth point in the data set:

```
% Read and display the ETOPO5 data from the folder 'etopo5'
% downsampled by a factor of 10.
[Z, refvec] = etopo5('etopo5',10);
axesm merc
geoshow(Z, refvec, 'DisplayType', 'surface');
demcmap(Z);
```

Example 2

Read in data for Korea and Japan at the full resolution:

```
samplefactor = 1; latlim = [30 45]; lonlim = [115 145];
[Z,refvec] = etopo5(samplefactor,latlim,lonlim);
whos Z
```

```
  Name      Size          Bytes  Class
  Z       180x360       518400  double array
```

See Also

`etopo` | `gtopo30` | `tbase` | `usgsdem`

Purpose

Field values from structure array

Syntax

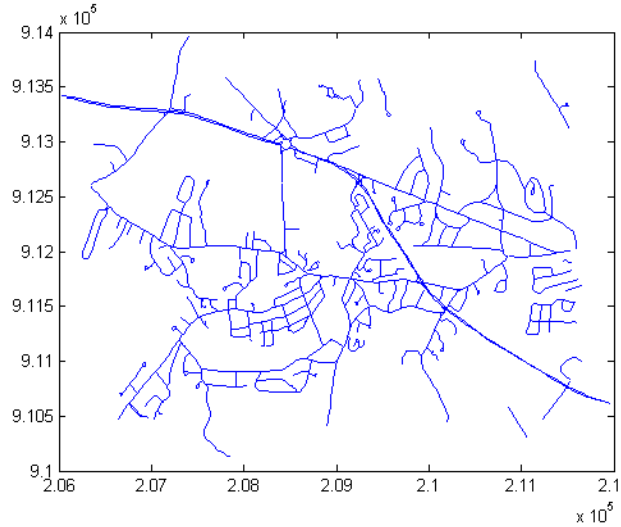
```
a = extractfield(s, name)
```

Description

`a = extractfield(s, name)` returns the field values specified by the field named `name` into the 1-by-n output array `a`. `n` is the total number of elements in the field `name` of structure `s`, that is, `n = numel([s(:).(name)])`. `name` is a case-sensitive string defining the field name of the structure `s`. `a` is a cell array if any field values in the field name contain a string or if the field values are not uniform in type; otherwise `a` is the same type as the field values. The shape of the input field is not preserved in `a`.

Examples

```
% Plot the X, Y coordinates of the road's shape
roads = shaperead('concord_roads.shp');
plot(extractfield(roads,'X'),extractfield(roads,'Y'));

% Extract the names of the roads
roads = shaperead('concord_roads.shp');
names = extractfield(roads,'STREETNAME');

% Extract a mix-type field into a cell array
S(1).Type = 0;
S(2).Type = logical(0);
mixedType = extractfield(S,'Type');
```



See Also

`struct` | `shaperead`

Purpose

Coordinate data from line or patch display structure

Syntax

```
[lat,lon] = extractm(display_struct,object_str)
[lat,lon] = extractm(display_struct,object_strings)
[lat,lon] = extractm(display_struct,object_strings,
   searchmethod)
[lat,lon] = extractm(display_struct)
[lat,lon,indx] = extractm(...)
mat = extractm(...)
```

Description

`[lat,lon] = extractm(display_struct,object_str)` extracts latitude and longitude coordinates from those elements of `display_struct` having `'tag'` fields that begin with the string specified by *`object_str`*. `display_struct` is a Mapping Toolbox display structure in which the `'type'` field has a value of either 'line' or `'patch'`. The output `lat` and `lon` vectors include NaNs to separate the individual map features. The comparison of `'tag'` values is not case-sensitive.

`[lat,lon] = extractm(display_struct,object_strings)`, where *`object_strings`* is a character array or a cell array of strings, selects features with `'tag'` fields matching any of several different strings. Character array objects will have trailing spaces stripped before matching.

`[lat,lon] = extractm(display_struct,object_strings,searchmethod)` controls the method used to match the values of the `'tag'` field in `display_struct`. *`searchmethod`* can be one of three strings:

`'strmatch'`	Search for matches at the beginning of the tag
`'findstr'`	Search within the tag
`'exact'`	Search for exact matches. Note that when *`searchmethod`* is specified the search is case-sensitive.

`[lat,lon] = extractm(display_struct)` extracts all vector data from the input map structure.

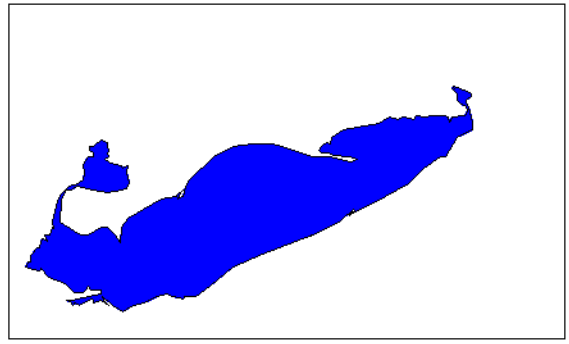
`[lat,lon,indx] = extractm(...)` also returns the vector `indx` identifying which elements of `display_struct` met the selection criteria.

`mat = extractm(...)` returns the vector data in a single matrix, where `mat = [lat lon]`.

Examples

Extract the District of Columbia from the low-resolution U.S. vector data:

```
load greatlakes
[lat, lon] = extractm(greatlakes, 'Erie');
axesm mercator
geoshow(lat,lon, 'DisplayType','polygon', 'FaceColor','blue')
```



Tips

A Version 1 display structure is a MATLAB structure that can contain line, patch, text, regular data grid, geolocated data grid, and certain other objects and fixed attributes. In Mapping Toolbox Version 2, a new data structure for vector geodata was introduced (called a *mapstruct* or a *geostruct*, depending on whether coordinates it contains are projected or unprojected). Geostructs and mapstructs have few required fields and can include any number of user-defined fields, giving them much greater flexibility to represent vector geodata. For information about

the contents and format of display structures, see "Version 1 Display Structures" on page 3-177 in the reference page for `displaym`. For information about converting display structures to geographic data structures, see the reference page for `updategeostruct`, which performs such conversions.

See Also

`displaym` | `extractfield` | `geoshow` | `mapshow` | `updategeostruct` | `mlayers`

fill3m

Purpose

Project filled 3-D patch objects on map axes

Syntax

```
h = fill3m(lat,lon,z,cdata)
h = fill3m(lat,lon,z,PropertyName,PropertyValue,...)
```

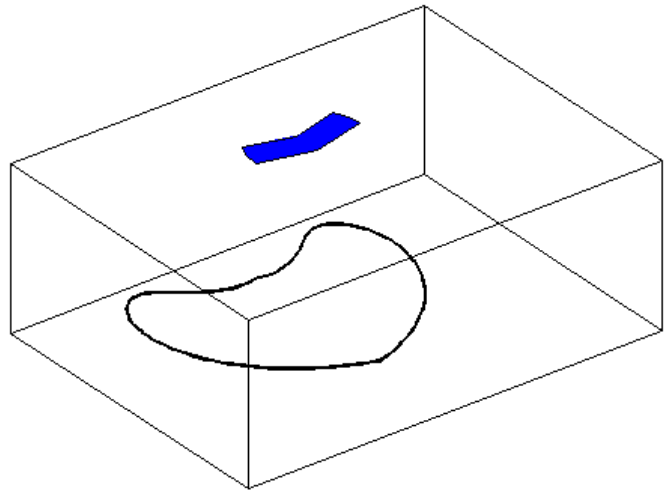
Description

`h = fill3m(lat,lon,z,cdata)` projects and displays any patch object with vertices defined by vectors `lat` and `lon` to the current map axes. The scalar `z` indicates the altitude plane at which the patch is displayed. The input `cdata` defines the patch face color. The patch handle or handles, `h`, can be returned.

`h = fill3m(lat,lon,z,PropertyName,PropertyValue,...)` allows any property name/property value pair supported by `patch` to be assigned to the `fill3m` object.

Examples

```
lat = [30 15 0 0 0 15 30 30]';
lon = [-60 -60 -60 0 60 60 60 0]';
axesm bonne; framem
view(3)
fill3m(lat,lon,2,'b')
```



See Also

`fillm` | `patchesm` | `patchm`

fillm

Purpose

Project filled 2-D patch objects on map axes

Syntax

```
h = fillm(lat,lon,cdata)
h = fillm(lat,lon,'PropertyName',PropertyValue,...)
```

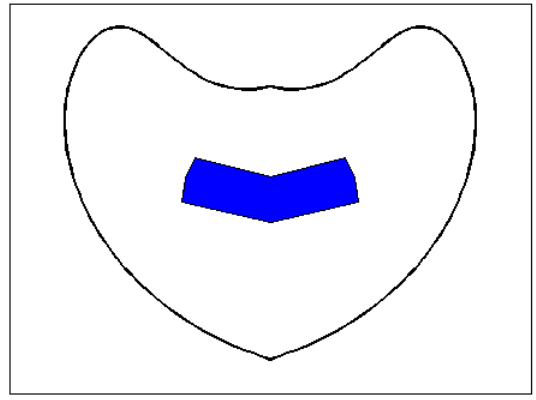
Description

`h = fillm(lat,lon,cdata)` projects and displays any patch object with vertices defined by the vectors `lat` and `lon` to the current map axes. The input `cdata` defines the patch face color. The patch handle or handles, `h`, can be returned.

`h = fillm(lat,lon,'PropertyName',PropertyValue,...)` allows any property name/property value pair supported by `patch` to be assigned to the `fillm` object.

Examples

```
lat = [30 15 0 0 0 15 30 30]';
lon = [-60 -60 -60 0 60 60 60 0]';
axesm bonne; framem
fillm(lat,lon,'b')
```



See Also

`fill3m` | `patchesm` | `patchm`

Purpose

Filter latitudes and longitudes based on underlying data grid

Syntax

```
[latout,lonout] = filterm(lat,lon,Z,R,allowed)
[latout,lonout,indx] = filterm(lat,lon,Z,R,allowed)
```

Description

`[latout,lonout] = filterm(lat,lon,Z,R,allowed)` filters a set of latitudes and longitudes to include only those data points which have a corresponding value in `Z` equal to `allowed`. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to or from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Nearest-neighbor interpolation is used by default. NaN is returned for points outside the grid limits or for which `lat` or `lon` contain NaN. All angles are in units of degrees.

`[latout,lonout,indx] = filterm(lat,lon,Z,R,allowed)` also returns the indices of the included points.

Examples

Filter a random set of 100 geographic points. Use the `topo` map for starters:

```
load topo
```

Then generate 100 random points:

```
lat = -90+180*rand(100,1);
long = -180+360*rand(100,1);
```

Make a land map, which is `1` where `topo>0` elevation:

```
land = topo>0;
[newlat,newlong] = filterm(lat,long,land,topolegend,1);
size(newlat)

ans =
    15     1
```

15 of the 100 random points fall on *land*.

See Also

`imbedm` | `hista` | `histr`

Purpose

Latitudes and longitudes of nonzero data grid elements

Syntax

```
[lat,lon] = findm(Z,R)
[lat,lon] = findm(latz,lonz,Z)
[lat,lon,val] = findm(...)
mat = findm(...)
```

Description

`[lat,lon] = findm(Z,R)` computes the latitudes and longitudes of the nonzero elements of a regular data grid, `Z`. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to or from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Nearest-neighbor interpolation is used by default. NaN is returned for points outside the grid limits or for which `lat` or `lon` contain NaN. All angles are in units of degrees.

`[lat,lon] = findm(latz,lonz,Z)` returns the latitudes and longitudes of the nonzero elements of a geolocated data grid `Z`, which is an M-by-N logical or numeric array. Typically `latz` and `lonz` are M-by-N latitude-longitude arrays, but `latz` may be a latitude vector of length M and `lonz` may be a longitude vector of length N.

`[lat,lon,val] = findm(...)` returns the values of the nonzero elements of `Z`, in addition to their locations.

`mat = findm(...)` returns a single output, where `mat = [lat lon]`.

This function works in two modes: with a regular data grid and with a geolocated data grid.

Examples

The data grid can be the result of a logical operation. For instance, you can find all locations with elevations greater than 5500 meters.

```
load topo
[lat, lon] = findm((topo>5500),topolegend);
[lat lon]

ans =
   34.5000   79.5000
   34.5000   80.5000
   30.5000   84.5000
   28.5000   86.5000
```

These points are in the Himalayas. Find the grid values at these locations with `setpostn`:

```
heights = topo(setpostn(topo,topolegend,lat,lon))

heights =
        5559
        5515
        5523
        5731
```

Use a regular data grid to retrieve the elevations from `setpostn`.

See Also

`find`

Purpose

Read Federal Information Processing Standard (FIPS) name file used with TIGER thinned boundary files

Syntax

```
struc = fipsname
struc = fipsname(filename)
```

Description

`struc = fipsname` opens a file selection window to pick the file, reads the FIPS codes, and returns them in a structure.

`struc = fipsname(filename)` reads the specified file.

Background

The TIGER thinned boundary files provided by the U.S. Census use FIPS codes to identify geographic entities. This function reads the FIPS files as provided with the TIGER files. These files generally have names of the format *_name.dat*.

Tips

The FIPS name files, along with TIGER thinned boundary files, are available over the Internet.

Examples

```
struc = fipsname('st_name.dat')

struc =
1x57 struct array with fields:
    name
    id

s(1)

ans =
    name: 'Alabama'
      id: 1
```

flat2ecc

Purpose

Eccentricity of ellipse from flattening

Syntax

```
ecc = flat2ecc(f)
ecc = flat2ecc(f)
```

Description

`ecc = flat2ecc(f)` computes the eccentricity of an ellipse (or ellipsoid of revolution) given its flattening `f`. Except when the input has 2 columns (or is a row vector), each element is assumed to be a flattening and the output `ecc` has the same size as `f`.

`ecc = flat2ecc(f)`, where `f` has two columns (or is a row vector), assumes that the second column is a flattening, and a column vector is returned.

See Also

`axes2ecc | ecc2flat | n2ecc`

Purpose

Insert points along date line to pole

Syntax

```
[latf,lonf] = flatearthpoly(lat,lon)
[latf,lonf] = flatearthpoly(lat,lon,longitudeOrigin)
```

Description

`[latf,lonf] = flatearthpoly(lat,lon)` trims NaN-separated polygons specified by the latitude and longitude vectors `lat` and `lon` to the limits [-180 180] in longitude and [-90 90] in latitude, inserting straight segments along the +/- 180-degree meridians and at the poles. Inputs and outputs are in degrees.

`[latf,lonf] = flatearthpoly(lat,lon,longitudeOrigin)` centers the longitude limits on the longitude specified by the scalar longitude `longitudeOrigin`.

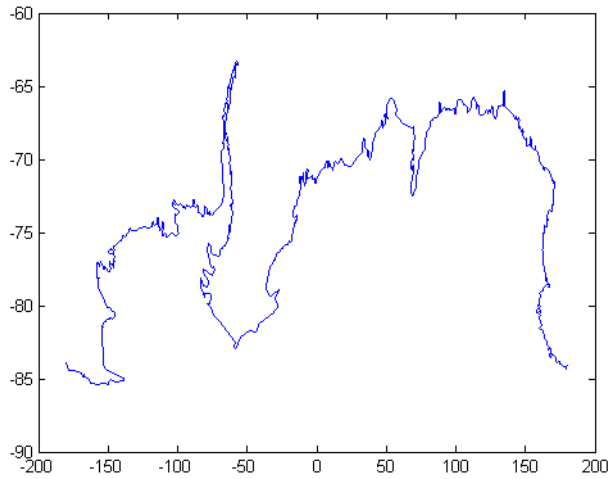
Tips

The polygon topology for the input vectors must be valid. This means that vertices for outer rings (main polygon or "island" polygons) must be in clockwise order, and any inner rings ("lakes") must run in counterclockwise order for the function to work properly. You can use the `ispolycw` function to check whether or not your `lat`, `lon` vectors meet this criterion, and the `poly2cw` and `poly2ccw` functions to correct any that run in the wrong direction.

Examples

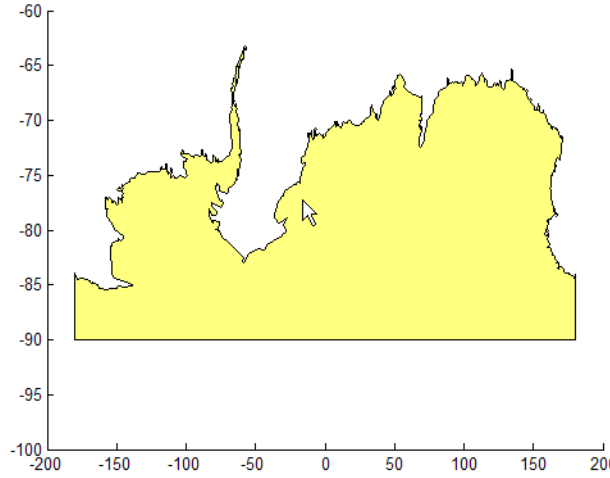
Vector data for geographic objects that encompass a pole will inevitably encounter or cross the date line. While the toolbox properly displays such polygons, they can cause problems for functions like the polygon intersection and Boolean operations that work with Cartesian coordinates. When these polygons are treated as Cartesian coordinates, the date line crossing results in a spurious line segment, and the polygon displayed as a patch does not have the interior filled correctly.

```
antarctica = shaperead('landareas', 'UseGeoCoords', true,...
    'Selector', {@(name) strcmp(name,'Antarctica'), 'Name'});
figure; plot(antarctica.Lon, antarctica.Lat); ylim([-100 -60])
```



The polygons can be reformatted more appropriately for Cartesian coordinates using the `flatearthpoly` function. The result resembles a map display on a cylindrical projection. The polygon meets the date line, drops down to the pole, sweeps across the longitudes at the pole, and follows the date line up to the other side of the date line crossing.

```
[latf, lonf] = flatearthpoly(antarctica.Lat', antarctica.Lon');
figure; mapshow(lonf, latf, 'DisplayType', 'polygon')
ylim([-100 -60])
xlim([-200 200])
axis square
```



See Also

ispolycw | maptrimp | poly2cw | poly2ccw

framem

Purpose

Toggle and control display of map frame

Syntax

```
framem
framem('on')
framem('off')
framem('reset')
framem(linespec)
framem(PropertyName,PropertyValue,...)
```

Description

`framem` toggles the visibility of the map frame by setting the map axes property `Frame` to `'on'` or `'off'`. The default setting for map axes is `'off'`.

`framem('on')` sets the map axes property `Frame` to `'on'`.

`framem('off')` sets the map axes property `Frame` to `'off'`.

When called with the string argument `'off'`, the map axes property `Frame` is set to `'off'`.

`framem('reset')` resets the entire frame using the current properties. This is essentially a *refresh* option.

`framem(linespec)` sets the map axes `FEdgeColor` property to the color component of any *`linespec`* string recognized by the MATLAB `line` function.

`framem(PropertyName,PropertyValue,...)` sets the appropriate map axes properties to the desired values. These property names and values are described on the `axesm` reference page.

Tips

- You can also create or alter map frame properties using the `axesm` or `setm` functions.
- By default the Clipping property is set to `'off'`. Override this setting with the following code:

```
hgrat = gridm('on');
set(hgrat,'Clipping','on')
```

See Also

axesm | setm

fromDegrees

Purpose

Convert angles from degrees

Syntax

```
[angle1, angle2, ...] = fromDegrees(toUnits,
angle1InDegrees,
   angle2InDegrees, ...)
```

Description

`[angle1, angle2, ...] = fromDegrees(`*`toUnits`*`, angle1InDegrees, angle2InDegrees, ...)` converts `angle1InDegrees, angle2InDegrees, ...` from degrees to the specified output ("to") angle units. *`toUnits`* can be either `'degrees'` or `'radians'` and may be abbreviated. The inputs `angle1InDegrees, angle2InDegrees, ...` and their corresponding outputs are numeric arrays of various sizes, with `size(angleN)` matching `size(angleNInDegrees)`.

See Also

`degtorad` | `fromRadians` | `toDegrees` | `toRadians`

Purpose

Convert angles from radians

Syntax

```
[angle1, angle2, ...] = fromRadians(toUnits,
angle1InRadians,
   angle2InRadians, ...)
```

Description

`[angle1, angle2, ...] = fromRadians(toUnits, angle1InRadians, angle2InRadians, ...)` converts `angle1InRadians, angle2InRadians, ...` from radians to the specified output ("to") angle units. *`toUnits`* can be either `'degrees'` or `'radians'` and may be abbreviated. The inputs `angle1InRadians, angle2InRadians, ...` and their corresponding outputs are numeric arrays of various sizes, with `size(angleN)` matching `size(angleNInRadians)`.

See Also

`fromDegrees` | `radtodeg` | `toDegrees` | `toRadians`

Purpose

Center and radius of great circle

Syntax

```
[lat,lon,radius] = gc2sc(lat0,lon0,az)
[lat,lon,radius] = gc2sc(lat0,lon0,az,angleunits)
mat = gc2sc(...)
```

Description

`[lat,lon,radius] = gc2sc(lat0,lon0,az)` converts a great circle from great circle notation (i.e., lat, lon, azimuth, where (lat, lon) is on the circle) to small circle notation (i.e., lat, lon, radius, where (lat, lon) is the center of the circle and the radius is 90 degrees, which is a definition of a great circle). A great circle has two centers and one is chosen arbitrarily. The other is its antipode. All inputs and outputs are in units of degrees.

`[lat,lon,radius] = gc2sc(lat0,lon0,az,angleunits)` uses the string `angleunits` to specify the angle units of the inputs and outputs. `angleunits` can equal either `'degrees'` or `'radians'`.

`mat = gc2sc(...)` returns a single output, where `mat = [lat lon radius]`.

Definitions

A *small circle* is the intersection of a plane with the surface of a sphere. A *great circle* is a small circle with a radius of 90º.

Examples

Represent a great circle passing through (25ºS,70ºW) on an azimuth of 45º as a small circle:

```
[lat,lon,radius] = gc2sc(-25,-70,45)

lat =
  -39.8557
lon =
   42.9098
radius =
    90
```

A great circle always bisects the sphere. As a demonstration of this statement, consider the Equator, which passes through any point with

a latitude of 0º and proceeds on an azimuth of 90º or 270º. Represent the Equator as a small circle:

```
[lat, lon, radius] = gc2sc(0,-70,270)

lat =
    90
lon =
 -145.9638
radius =
    90
```

Not surprisingly, the small circle is centered on the North Pole. As always at the poles, the longitude is arbitrary because of the convergence of the meridians.

Note that the center coordinates returned by this function always lead to one of two possibilities. Since the great circle bisects the sphere, the antipode of the returned point is also a center with a radius of 90º. In the above example, the South Pole would also be a suitable center for the Equator in a small circle.

See Also

`antipode` | `crossfix` | `gcxgc` | `gcxsc` | `rhxrh`

Purpose

Current map projection structure

Syntax

```
mstruct = gcm
mstruct = gcm(hndl)
```

Description

`mstruct = gcm` returns the map axes *map structure*, which contains the settings for all the current map axes properties.

`mstruct = gcm(hndl)` specifies the map axes by axes handle.

Examples

Establish a map axes with default values, then look at the structure:

```
axesm mercator
mstruct = gcm

mstruct =
     mapprojection: 'mercator'
              zone: []
        angleunits: 'degrees'
            aspect: 'normal'
     falsenorthing: 0
      falseeasting: 0
       fixedorient: []
             geoid: [1 0]
       maplatlimit: [-86 86]
       maplonlimit: [-180 180]
      mapparallels: 0
        nparallels: 1
            origin: [0 0 0]
       scalefactor: 1
           trimlat: [-86 86]
           trimlon: [-180 180]
             frame: 'off'
             ffill: 100
        fedgecolor: [0 0 0]
        ffacecolor: 'none'
         flatlimit: [-86 86]
```

```
    flinewidth: 2
     flonlimit: [-180 180]
          grid: 'off'
     galtitude: Inf
        gcolor: [0 0 0]
    glinestyle: ':'
    glinewidth: 0.5000
mlineexception: []
     mlinefill: 100
    mlinelimit: []
 mlinelocation: 30
  mlinevisible: 'on'
plineexception: []
     plinefill: 100
    plinelimit: []
 plinelocation: 15
  plinevisible: 'on'
     fontangle: 'normal'
     fontcolor: [0 0 0]
      fontname: 'Helvetica'
      fontsize: 10
     fontunits: 'points'
    fontweight: 'normal'
   labelformat: 'compass'
 labelrotation: 'off'
    labelunits: 'degrees'
 meridianlabel: 'off'
mlabellocation: 30
mlabelparallel: 86
   mlabelround: 0
 parallellabel: 'off'
plabellocation: 15
plabelmeridian: -180
   plabelround: 0
```

Tips

You create map structure properties with the `axesm` function. You can query them with the `getm` function and modify them with the `setm` function.

See Also

`axesm` | `getm` | `setm`

Purpose

Current mouse point from map axes

Syntax

```
pt = gcpmap
pt = gcpmap(hndl)
```

Description

`pt = gcpmap` returns the current point (the location of last button click) of the current map axes in the form `[latitude longitude z-altitude]`.

`pt = gcpmap(hndl)` specifies the map axes in question by its handle.

Tips

`gcpmap` works much like the standard MATLAB function `get(gca,'CurrentPoint')`, except that the returned matrix is in `[lat lon z]`, not `[x y z]`.

You must use `view(2)` and an ordinary projection (not the Globe projection) when working with the `gcpmap` function.

The `CurrentPoint` property is updated whenever a button-click event occurs in a MATLAB figure window. The pointer does not have to be within the axes, or even the figure window. Coordinates with respect to the requested axes are returned regardless of the pointer location. Likewise, `gcpmap` will return values that may look reasonable whether the current point is within the graticule bounds or not, and thus must be used with care.

Examples

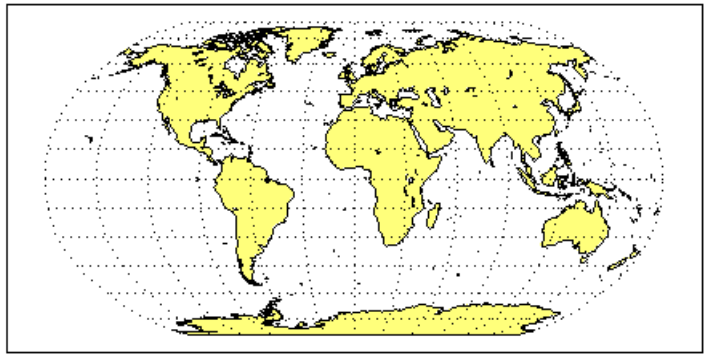
Set up a map axes with a graticule and display a world map:

```
axesm robinson
gridm on
geoshow('landareas.shp')
```

Click somewhere near Boston, Massachusetts to obtain a current point:

```
pt = gcpmap

pt =
       44.171      -69.967            2
```

```
       44.171      -69.967            0
whos

  Name      Size                    Bytes  Class          Attributes
  pt        2x3                        48  double array
```



See Also

`inputm`

How To

- Axes Properties

Purpose

Equally spaced waypoints along great circle

Syntax

```
[lat,lon] = gcwaypts(lat1,lon1,lat2,lon2)
[lat,lon] = gcwaypts(lat1,lon1,lat2,lon2,nlegs)
pts = gcwaypts(lat1,lon1,lat2,lon2...)
```

Description

`[lat,lon] = gcwaypts(lat1,lon1,lat2,lon2)` returns the coordinates of equally spaced points along a great circle path connecting two endpoints, (`lat1,lon1`) and (`lat2,lon2`).

`[lat,lon] = gcwaypts(lat1,lon1,lat2,lon2,nlegs)` specifies the number of equal-length track legs to calculate. `nlegs+1` output points are returned, since a final endpoint is required. The default number of legs is 10.

`pts = gcwaypts(lat1,lon1,lat2,lon2...)` packs the outputs, which are otherwise two-column vectors, into a two-column matrix of the form `[latitude longitude]`. This format for successive waypoints along a navigational track is called *navigational track format* in this guide. See the `navigational track format` reference page in this section for more information.

Background

This is a navigational function. It assumes that all latitudes and longitudes are in degrees.

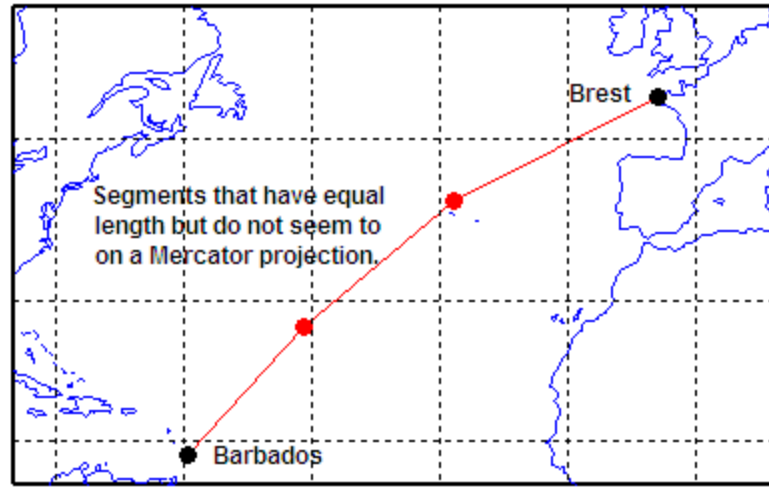
In navigational practice, great circle paths are often approximated by rhumb line segments. This is done to come reasonably close to the shortest distance between points without requiring course changes too frequently. The `gcwaypts` function provides an easy means of finding waypoints along a great circle path that can serve as endpoints for rhumb line segments (track legs).

Examples

Imagine you own a sailing yacht and are planning a voyage from North Point, Barbados (13.33º N,59.62ºW), to Brest, France (48.36ºN,4.49ºW). To divide the track into three equal-length segments,

```
figure('color','w');
ha = axesm('mapproj','mercator',...
```

```
    'maplatlim',[10 55],'maplonlim',[-80 10],...
    'MLineLocation',15,'PLineLocation',15);
axis off, gridm on, framem on;
load coast;
hg = geoshow(lat,long,'displaytype','line','color','b');
% Define point locations for Barbados and Brest
barbados = [13.33 -59.62];
brest = [48.36 -4.49];
[l,g] = gcwaypts(barbados(1),barbados(2),brest(1),brest(2),3);
geoshow(l,g,'displaytype','line','color','r',...
    'markeredgecolor','r','markerfacecolor','r','marker','o');
geoshow(barbados(1),barbados(2),'DisplayType','point',...
    'markeredgecolor','k','markerfacecolor','k','marker','o')
geoshow(brest(1),brest(2),'DisplayType','point',...
    'markeredgecolor','k','markerfacecolor','k','marker','o')
```



See Also

dreckon | legs | navfix | track

Purpose

Intersection points for pairs of great circles

Syntax

```
[newlat,newlong] = gcxgc(lat1,long1,az1,lat2,long2,az2)
[newlat,newlong] =
gcxgc(lat1,long1,az1,lat2,long2,az2,units)
```

Description

`[newlat,newlong] = gcxgc(lat1,long1,az1,lat2,long2,az2)` returns the two intersection points of pairs of great circles input in *great circle notation*. When the two great circles are identical (which is not, in general, apparent by inspection), two `NaN`s are returned instead and a warning is displayed. For multiple pairings, the inputs must be column vectors.

`[newlat,newlong] = gcxgc(lat1,long1,az1,lat2,long2,az2,units)` specifies the standard angle unit string. The default value is `'degrees'`.

For any pair of great circles, there are two possible intersection conditions: the circles are identical or they intersect exactly twice on the sphere.

Great circle notation consists of a point on the great circle and the azimuth at that point along which the great circle proceeds.

Examples

Given a great circle passing through (10ºN,13ºE) and proceeding on an azimuth of 10º, where does it intersect with a great circle passing through (0º, 20ºE), on an azimuth of -23º (that is, 337º)?

```
[newlat,newlong] = gcxgc(10,13,10,0,20,-23)

newlat =
   14.3105  -14.3105
newlong =
   13.7838  -166.2162
```

Note that the two intersection points are always antipodes of each other. As a simple example, consider the intersection points of two meridians, which are just great circles with azimuths of 0º or 180º:

```
[newlat,newlong] = gcxgc(10,13,0,0,20,180)

newlat =
   -90    90
newlong =
   -174.4504   12.5094
```

The two meridians intersect at the North and South Poles, which is exactly correct.

See Also

antipode | gc2sc | scxsc | gcxsc | rhxrh | crossfix | polyxpoly

Purpose

Intersection points for great and small circle pairs

Syntax

```
[newlat,newlong] = gcxsc(gclat,gclong,gcaz,sclat,sclong,
   scrange)
[newlat,newlong] = gcxsc(...,units)
```

Description

`[newlat,newlong] = gcxsc(gclat,gclong,gcaz,sclat,sclong,scrange)` returns the points of intersection of a great circle in *great circle notation* followed by a small circle in *small circle notation*. For multiple pairings, the inputs must be column vectors. The results are two-column matrices with the coordinates of the intersection points. If the circles do not intersect, or are identical, two `NaN`s are returned and a warning is displayed. If the two circles are tangent, the single intersection point is repeated twice.

`[newlat,newlong] = gcxsc(...,units)` specifies the standard angle unit string. The default value is `'degrees'`.

For a pairing of a great circle with a small circle, there are four possible intersection conditions: the circles are identical (possible because great circles are a subset of small circles), they do not intersect, they are tangent to each other (the small circle interior to the great circle) and hence they intersect once, or they intersect twice.

Great circle notation consists of a point on the great circle and the azimuth at that point along which the great circle proceeds.

Small circle notation consists of a center point and a radius in units of angular arc length.

Examples

Given a great circle passing through (43ºN,0º) and proceeding on an azimuth of 10º, where does it intersect with a small circle centered at (47ºN,3ºE) with an arc length radius of 12º?

```
[newlat,newlong] = gcxsc(43,0,10,47,3,12)

newlat =
   35.5068   58.9143
newlong =
```

```
    -1.6159    5.4039
```

See Also

gc2sc | gcxgc | scxsc | rhxrh | crossfix | polyxpoly

Purpose

Convert geocentric to geodetic latitude

Syntax

```
phiI = geocentric2geodeticlat(ecc, phi_g)
```

Description

`phiI = geocentric2geodeticlat(ecc, phi_g)` converts an array of geocentric latitude in radians, `phi_g`, to geodetic latitude in radians, `phiI`, on a reference ellipsoid with first eccentricity `ecc`.

For conversion to/from other types of auxiliary latitude and, optionally, to work in degrees, use Mapping Toolbox function `convertlat`. For conversion from 3-D geocentric coordinates, see `ecef2geodetic`.

See Also

`convertlat` | `ecef2geodetic` | `geodetic2geocentricLat`

oblateSpheroid

Purpose

Oblate ellipsoid of revolution

Description

An oblate spheroid object encapsulates the interrelated intrinsic properties of an oblate ellipsoid of revolution. An oblate spheroid is symmetric about its polar axis and flattened at the poles, and includes the perfect sphere as a special case.

Construction

`S = oblateSpheroid` returns an oblate spheroid object.

Properties

SemimajorAxis

Equatorial radius of spheroid, `a`

When set to a new value, the `SemiminorAxis` property scales as needed to preserve the shape of the spheroid and the values of shape-related properties including `InverseFlattening` and `Eccentricity`.

The only way to change the `SemimajorAxis` property is to set it directly.

DataType: Positive, finite scalar.

Default: `1`

SemiminorAxis

Distance from center of spheroid to pole, `b`

The value is always less than or equal to `SemimajorAxis` property. When set to a new value, the `SemimajorAxis` property remains unchanged, but the shape of the spheroid changes, which is reflected in changes in the values of `InverseFlattening`, `Eccentricity`, and other shape-related properties.

DataType: Nonnegative, finite scalar.

Default: `0`

InverseFlattening

Reciprocal of flattening.

`1/f = a/(a-b)`, where `a` and `b` are the semimajor and semiminor axes. A value of `1/f = Inf` designates a perfect sphere. As `1/f` value approaches 1, the spheroid approaches a flattened disk. When set to a new value, other shape-related properties are updated, including `Eccentricity`. The `SemimajorAxis` value is unaffected by changes to `1/f`, but the value of the `SemiminorAxis` property adjusts to reflect the new shape.

DataType: Positive scalar in the interval `[1 Inf]`.

Default: `1`

Eccentricity

First eccentricity of spheroid, `ecc = sqrt(a^2-b^2)/a`

It is the normalized distance from the center to foci in the meridional plane. A value of 0 designates a perfect sphere. When set to a new value, other shape-related properties update, including `InverseFlattening`. The `SemimajorAxis` value is unaffected by changes to `ecc`, but the value of the `SemiminorAxis` property adjusts to reflect the new shape.

DataType: Nonnegative scalar less than or equal to 1.

Default: `1`

Flattening

Flattening of spheroid

`f = (a-b)/a`, where `a` and `b` are semimajor and semiminor axes of spheroid.

Access: Read only

ThirdFlattening

Third flattening of spheroid

`n = (a-b)/(a+b)`, where `a` and `b` are the semimajor and semiminor axes of spheroid.

Access: Read only

MeanRadius

Mean radius of spheroid, `(2*a+b)/3`

The `MeanRadius` property uses the same unit of length as the `SemimajorAxis` and `SemiminorAxis` properties.

Access: Read only

SurfaceArea

Surface area of spheroid

The `SurfaceArea` is expressed in units of area consistent with the unit of length used for the`SemimajorAxis` and `SemiminorAxis` properties.

Access: Read only

Volume

Volume of spheroid

The `Volume` is expressed in units of volume consistent with the unit of length used for the `SemimajorAxis` and `SemiminorAxis` properties.

Access: Read only

Note When you define a spheroid in terms of semimajor and semiminor axes (rather than semimajor axis and inverse flattening or semimajor axis and eccentricity), a small loss of precision in the last few digits of `f`, `ecc`, and `n` is possible. This is unavoidable, but does not affect the results of practical computation.

Methods

ecef2geodetic	Transform geocentric (ECEF) to geodetic coordinates
ecefOffset	Cartesian ECEF offset between geodetic positions
geodetic2ecef	Transform geodetic to geocentric (ECEF) coordinates

Copy Semantics

Value. To learn how value classes affect copy operations, see Copying Objects.

Examples

Create GRS 80 ellipsoid

Create a GRS 80 ellipsoid using the `oblateSpheroid` class.

Start with a unit sphere by default.

```
    s = oblateSpheroid
```

```
s =
  oblateSpheroid

  Properties:
        SemimajorAxis: 1
        SemiminorAxis: 1
    InverseFlattening: Inf
         Eccentricity: 0
```

Reset the semimajor axis to match the equatorial radius of the GRS 80 reference ellipsoid.

```
    s.SemimajorAxis = 6378137
```

```
s =
  oblateSpheroid
```

```
  Properties:
        SemimajorAxis: 6378137
        SemiminorAxis: 6378137
    InverseFlattening: Inf
         Eccentricity: 0
```

The result is a sphere with radius 6,378,137 meters.

Reset the inverse flattening to the standard value for GRS 80, resulting in an oblate spheroid with a semiminor axis consistent with the value, 6,356,752.3141, tabulated in DMA Technical Memorandum 8358.1, "Datums, Ellipsoids, Grids, and Grid Reference Systems."

```
    s.InverseFlattening = 298.257222101

s =
  oblateSpheroid

  Properties:
        SemimajorAxis: 6378137
        SemiminorAxis: 6356752.31414036
    InverseFlattening: 298.257222101
         Eccentricity: 0.0818191910428158
```

See Also

`referenceEllipsoid` | `referenceSphere` |

Purpose

Transform geodetic to geocentric (ECEF) coordinates

Syntax

```
[X,Y,Z] = geodetic2ecef(spheroid,lat,lon,h)
[X,Y,Z] = geodetic2ecef( ___ , angleUnit)
```

Description

`[X,Y,Z] = geodetic2ecef(spheroid,lat,lon,h)` returns Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian coordinates corresponding to geodetic coordinates `lat`, `lon`, `h`. Any of the three numerical arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[X,Y,Z] = geodetic2ecef( ___ , angleUnit)` adds `angleUnit` which specifies the units of inputs lat and lon.

Input Arguments

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

lat - Geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types

single | double

lon - Longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h - Ellipsoidal heights
scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

angleUnit - Units of angles
`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

X - ECEF x-coordinates
scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

Y - ECEF y-coordinates
scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

Z - ECEF y-coordinates
scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D

array. Units are determined by the `LengthUnit` property of the `spheroid` object.

See Also

`oblateSpheroid.ecef2geodetic` | `oblateSpheroid.ecefOffset` |

oblateSpheroid.ecef2geodetic

Purpose

Transform geocentric (ECEF) to geodetic coordinates

Syntax

```
[lat,lon,h] = ecef2geodetic(spheroid,X,Y,Z)
[lat,lon,h] = ecef2geodetic( ___ , angleUnit)
```

Description

`[lat,lon,h] = ecef2geodetic(spheroid,X,Y,Z)` returns geodetic coordinates corresponding to coordinates `X`, `Y`, `Z` in an Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian system. Any of the three numerical arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[lat,lon,h] = ecef2geodetic( ___ , angleUnit)` adds `angleUnit` which specifies the units of outputs lat and lon.

Input Arguments

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

X - ECEF x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types

single | double

Y - ECEF y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

Z - ECEF z-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

lat - Geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the closed interval [-90 90].

lon - Longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the interval [-180 180].

h - Ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object

See Also

`oblateSpheroid.geodetic2ecef` | `oblateSpheroid.ecefOffset` |

Purpose

Cartesian ECEF offset between geodetic positions

Syntax

```
[U,V,W] = ecefOffset(spheroid,lat1,lon1,h1,lat2,lon2,h2)
[U,V,W] = ecefOffset( ___ , angleUnit)
```

Description

`[U,V,W] = ecefOffset(spheroid,lat1,lon1,h1,lat2,lon2,h2)` returns the components of the 3-D offset vector from an initial geodetic position specified by`lat1`,`lon1`,`h1` to a final position specified by `lat2`,`lon2`,`h2` with respect to an Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian system. Any of the six numerical arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[U,V,W] = ecefOffset( ___ , angleUnit)` adds `angleUnit` which specifies the units of inputs lat1, lon1, lat2, and lon2.

Input Arguments

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

lat1 - Initial geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more initial positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument angleUnit, if supplied, and in degrees, otherwise.

Data Types

single | double

lon1 - Initial longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more initial positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument angleUnit, if supplied, and in degrees, otherwise.

Data Types
single | double

h1 - Initial ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more initial positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the LengthUnit property of the spheroid object.

Data Types
single | double

lat2 - Final geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more final positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument angleUnit, if supplied, and in degrees, otherwise.

Data Types
single | double

lon2 - Final longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more final positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument angleUnit, if supplied, and in degrees, otherwise.

Data Types
single | double

h2 - Final ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more final positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the LengthUnit property of the spheroid object.

Data Types
single | double

angleUnit - Units of angles
`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

U - Offset vector x-components in ECEF system
scalar value | vector | matrix | N-D array

x-components of one or more Cartesian offset vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Values equal the difference in ECEF x-coordinates between initial and final positions. Units are determined by the LengthUnit property of the spheroid object.

V - Offset vector y-components in ECEF system
scalar value | vector | matrix | N-D array

y-components of one or more Cartesian offset vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Values equal the difference in ECEF y-coordinates between initial and final positions. Units are determined by the LengthUnit property of the spheroid object.

W - Offset vector z-components in ECEF system
scalar value | vector | matrix | N-D array

z-components of one or more Cartesian offset vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Values equal the difference in ECEF z-coordinates between initial and final positions. Units are determined by the LengthUnit property of the spheroid object.

See Also

`oblateSpheroid.geodetic2ecef` | `oblateSpheroid.ecef2geodetic` |

geodetic2aer

Purpose

Geodetic to local spherical AER

Syntax

```
[az,elev,slantRange] = geodetic2aer(lat,lon,h,lat0,lon0,h0,
   spheroid)
[ ___ ] = geodetic2aer( ___ ,angleUnit)
```

Description

`[az,elev,slantRange] = geodetic2aer(lat,lon,h,lat0,lon0,h0,spheroid)` returns coordinates in a local spherical system corresponding to geodetic coordinates `lat`, `lon`, `h`. Any of the first six numeric input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = geodetic2aer( ___ ,angleUnit)` adds `angleUnit` which specifies the units of inputs `lat`, `lon`, `lat0`, `lon0`, and outputs `az`, `elev`.

Input Arguments

lat - Geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon - Longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h - Ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h0 - Ellipsoidal height of local origin

scalar value | vector | matrix | N-D array

Ellipsoidal height of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one

origin (reference) point, and the value of `h0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

spheroid - Reference spheroid
scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

angleUnit - Units of angles
`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

az - Azimuth angles
scalar value | vector | matrix | N-D array

Azimuth angles in the local spherical system, returned as a scalar value, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the half-open interval [0 360).

elev - Elevation angles
scalar value | vector | matrix | N-D array

Elevation angles in the local spherical system, returned as a scalar value, vector, matrix, or N-D array. Elevations are with respect to a plane perpendicular to the spheroid surface normal. Units determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the closed interval [-90 90].

slantRange - Distances from local origin
scalar value | vector | matrix | N-D array

Distances from origin in the local spherical system, returned as a scalar value, vector, matrix, or N-D array. The straight-line, 3-D Cartesian distance is computed. Units are determined by the `LengthUnit` property of the `spheroid` input.

Examples

Zermatt to the Matterhorn

Compute the azimuth (in degrees), elevation angle (in degrees), and line of sight distance from Zermatt, Switzerland to the summit of the Matterhorn (Monte Cervino). All distances and lengths are in meters.

Origin (reference point): Zermatt.

```
fmt = get(0,'Format');
format short g

lat0 = dm2degrees([46  1]) % convert degree-minutes to degrees
lon0 = dm2degrees([ 7 45])
hOrthometric0 = 1620;
hGeoid = 53;
h0 = hOrthometric0 + hGeoid
```

```
lat0 =

       46.017


lon0 =

         7.75


h0 =

         1673
```

Point of Interest: Summit of Matterhorn.

```
lat = dms2degrees([45 58 35])
lon = dms2degrees([ 7 39 30])
hOrthometric = 4478;
hGeoid = 53;
h = hOrthometric + hGeoid
```

```
lat =

       45.976


lon =

       7.6583


h =

        4531
```

Azimuth, elevation angle, and slant range (line of sight distance) from Zermatt to Matterhorn summit.

```
[az,elev,slantRange] = geodetic2aer( ...
    lat,lon,h,lat0,lon0,h0,wgs84Ellipsoid)

format(fmt)
```

```
az =

        237.8


elev =
```

```
        18.755

slantRange =

        8871.7
```

See Also

aer2geodetic | ecef2aer | geodetic2enu | geodetic2ned

geodetic2ecef

Purpose

Convert geodetic to geocentric (ECEF) coordinates

Syntax

```
[x,y,z] = geodetic2ecef(phi,lambda,h,ellipsoid)
```

Description

`[x,y,z] = geodetic2ecef(phi,lambda,h,ellipsoid)` converts geodetic point locations specified by the coordinate arrays `phi` (geodetic latitude in radians), `lambda` (longitude in radians), and `h` (ellipsoidal height) to geocentric Cartesian coordinates `x`, `y`, and `z`. `ellipsoid` is a `referenceEllipsoid` (`oblateSpheroid`) object, a `referenceSphere` object, or a vector of the form `[semimajor axis, eccentricity]`. `h` must use the same units as the semimajor axis; `x`, `y`, and `z` will be expressed in these units, also.

Definitions

The geocentric Cartesian coordinate system is fixed with respect to the Earth, with its origin at the center of the ellipsoid and its *x*-, *y*-, and *z*-axes intersecting the surface at the locations listed in the table below.

Axis	Latitude where axis intersects surface	Longitude where axis intersects surface	Description
x	0	0	Equator/Prime Meridian
y	0	90º E	Equator/90º E meridian
z	90º N	NA	North Pole

A common synonym is Earth-Centered, Earth-Fixed coordinates, or ECEF.

See Also

`ecef2geodetic` | `ecef2lv` | `geodetic2geocentricLat` | `lv2ecef`

Purpose

Geodetic to local Cartesian ENU

Syntax

```
[xEast,yNorth,zUp] = geodetic2enu(lat,lon,h,lat0,lon0,h0,
   spheroid)
[xEast,yNorth,zUp] = geodetic2enu( ___ ,angleUnit)
```

Description

`[xEast,yNorth,zUp] = geodetic2enu(lat,lon,h,lat0,lon0,h0,spheroid)` returns coordinates in a local east-north-up (ENU) Cartesian system corresponding to geodetic coordinates `lat`, `lon`, `h`. Any of the first six numeric input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[xEast,yNorth,zUp] = geodetic2enu( ___ ,angleUnit)` adds `angleUnit` which specifies the units of inputs `lat`, `lon`, `lat0`, and `lon0`.

Input Arguments

lat - Geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon - Longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h - Ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h0 - Ellipsoidal height of local origin

scalar value | vector | matrix | N-D array

Ellipsoidal height of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one

origin (reference) point, and the value of `h0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

spheroid - Reference spheroid
scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

angleUnit - Units of angles
`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

xEast - Local ENU x-coordinates
scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the local ENU system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` input.

yNorth - Local ENU y-coordinates
scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the local ENU system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` input.

zUp - Local ENU z-coordinates
scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the local ENU system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` input.

See Also

`ecef2enu` | `enu2geodetic` | `geodetic2aer` | `geodetic2ned`

Purpose

Geodetic to local Cartesian NED

Syntax

```
[xNorth,yEast,zDown] = geodetic2enu(lat,lon,h,lat0,lon0,h0,
   spheroid)
[ ___ ] = geodetic2enu( ___ ,angleUnit)
```

Description

`[xNorth,yEast,zDown] = geodetic2enu(lat,lon,h,lat0,lon0,h0,spheroid)` returns coordinates in a local north-east-down (NED) Cartesian system to geodetic coordinates `lat`, `lon`, `h`. Any of the first six numeric input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = geodetic2enu( ___ ,angleUnit)` adds `angleUnit` which specifies the units of inputs `lat`, `lon`, `lat0`, and `lon0`.

Input Arguments

lat - Geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon - Longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h - Ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h0 - Ellipsoidal height of local origin

scalar value | vector | matrix | N-D array

Ellipsoidal height of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `h0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in

units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

xNorth - Local NED x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the local NED system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` input.

yEast - Local NED y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the local NED system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` input.

zDown - Local NED z-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the local NED system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` input.

See Also ecef2ned | ned2geodetic | geodetic2aer | geodetic2enu

Purpose

Convert geodetic to geocentric latitude

Syntax

```
phi_g = geodetic2geocentriclat(ecc, phi)
```

Description

`phi_g = geodetic2geocentriclat(ecc, phi)` converts an array of geodetic latitude in radians, `phi`, to geocentric latitude in radians, `phi_g`, on a reference ellipsoid with first eccentricity `ecc`.

For conversion to/from other types of auxiliary latitude and, optionally, to work in degrees, use Mapping Toolbox function `convertlat`. For conversion to 3-D geocentric coordinates, see `geodetic2ecef`.

See Also

`convertlat` | `geocentric2geodeticLat` | `geodetic2ecef`

geoloc2grid

Purpose

Convert geolocated data array to regular data grid

Syntax

```
[Z, refvec] = geoloc2grid(lat, lon, A, cellsize)
```

Description

`[Z, refvec] = geoloc2grid(lat, lon, A, cellsize)` converts the geolocated data array `A`, given geolocation points in `lat` and `lon`, to produce a regular data grid, `Z`, and the corresponding three-element referencing vector `refvec`. `cellsize` is a scalar that specifies the width and height of data cells in the regular data grid, using the same angular units as `lat` and `lon`. Data cells in `Z` falling outside the area covered by `A` are set to `NaN`.

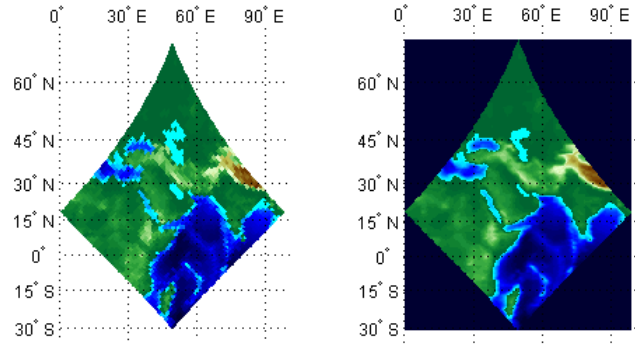
Tips

`geoloc2grid` provides an easy-to-use alternative to gridding geolocated data arrays with `imbedm`. There is no need to preallocate the output map; there are no data gaps in the output (even if `cellsize` is chosen to be very small), and the output map is smoother.

Examples

```
% Load the geolocated data array 'map1'
% and grid it to 1/2-degree cells.
load mapmtx
cellsize = 0.5;
[Z, refvec] = geoloc2grid(lt1, lg1, map1, cellsize);

% Create a figure
f = figure;
[cmap,clim] = demcmap(map1);
set(f,'Colormap',cmap,'Color','w')

% Define map limits
latlim = [-35 70];
lonlim = [0 100];

% Display 'map1' as a geolocated data array in subplot 1
subplot(1,2,1)
ax = axesm('mercator','MapLatLimit',latlim,...
   'MapLonLimit',lonlim,'Grid','on',...
```

```
   'MeridianLabel','on','ParallelLabel','on');
set(ax,'Visible','off')
geoshow(lt1, lg1, map1, 'DisplayType', 'texturemap');

% Display 'Z' as a regular data grid in subplot 2
subplot(1,2,2)
ax = axesm('mercator','MapLatLimit',latlim,...
   'MapLonLimit',lonlim,'Grid','on',...
   'MeridianLabel','on','ParallelLabel','on');
set(ax,'Visible','off')
geoshow(Z, refvec, 'DisplayType', 'texturemap');
```



geopoint

Purpose

Geographic point vector

Syntax

```
p = geopoint()
p = geopoint(lat,lon)
p = geopoint(lat,lon,Name,Value)
p = geopoint(structArray)
p = geopoint(lat,lon,structArray)
```

Description

A geopoint vector is a container object that holds geographic point coordinates and attributes. The points are coupled, such that the size of the latitude and longitude coordinate arrays are always equal and match the size of any dynamically added attribute arrays. Each entry of a coordinate pair and associated attributes, if any, represent a discrete element in the geopoint vector.

Construction

`p = geopoint()` constructs an empty geopoint vector, `p`, with these default property settings:

```
p =

 0x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: []
    Longitude: []
```

`p = geopoint(lat,lon)` constructs a new geopoint vector and assigns the `Latitude` and `Longitude` properties to the numeric array inputs, `lat` and `lon`. For examples, see “geopoint vector Using Latitude and Longitude Coordinates” on page 3-340 .

`p = geopoint(lat,lon,Name,Value)` constructs a geopoint vector from input arrays `lat` and `lon`, and then adds dynamic properties to the geopoint vector using the `Name`, `Value` argument pairs.

- If a specified name is `Metadata` and the corresponding value is a scalar structure, then the value is copied to the `Metadata` property. Otherwise, an error is issued.

See "geopoint vector Using a Name-Value pair" on page 3-341 for examples.

`p = geopoint(structArray)` constructs a new `geopoint` vector from the fields of the structure, `structArray`.

- If `structArray` contains the field `Lat`, and does not contain a field `Latitude`, then the `Lat` values are assigned to the `Latitude` property.
- If `structArray` contains both `Lat` and `Latitude` fields, then both field values are assigned to `p`.
- If `structArray` contains the field, `Lon`, and does not contain a field, `Longitude`, then the `Lon` values are assigned to the `Longitude` property.
- If `structArray` contains both `Lon` and `Longitude` fields, then both field values are assigned to `p`.
- If `structArray` is a scalar structure containing the field `Metadata` and the field value is a scalar structure, then the `Metadata` field is copied to the `Metadata` property. Otherwise, an error is issued if the `Metadata` field is not a structure, or ignored if `structArray` is not scalar.
- Other fields of `structArray` are assigned to `p` and become dynamic properties. Field values in `structArray` that are not numeric or strings or cell arrays of numeric or string values are ignored.

See "geopoint vector Using a Structure Array" on page 3-342 for an example.

`p = geopoint(lat,lon,structArray)` constructs a new `geopoint` vector and assigns the `Latitude` and `Longitude` properties to the numeric arrays, `lat` and `lon`, and sets dynamic properties from the field values of the structure, `structArray`.

- If `structArray` contains the fields `Lat`, `Latitude`, `Lon` or `Longitude`, then those field values are ignored.
- If `structArray` is a scalar structure containing the field `Metadata`, and the field value is a scalar structure, then it is copied to the `Metadata` property. Otherwise, an error is issued if the `Metadata` field is not a structure, or ignored if `structArray` is not scalar.

See "geopoint vector Using Numeric Arrays and a Structure Array" on page 3-343.

Input Arguments

lat

vector of latitude coordinates

Data Types
double | single

lon

vector of longitude coordinates

Data Types
double | single

structArray

structure containing fields to be assigned as dynamic properties to `p`.

Name

Name of dynamic property

Data Types
char

Value

Property value associated with dynamic property `Name`. Values may be numeric, logical, char, or a cell array of strings.

Output Arguments

p

geopoint vector.

Properties

Each element in a geopoint vector is considered a feature. Feature properties contain one value (a scalar number or a string) for each element in the geopoint vector. The `Latitude` and `Longitude` coordinate properties are feature properties as there is one value for each feature.

`Geometry` and `Metadata` are collection properties. These properties contain only one value per class instance. The term *collection* is used to distinguish these two properties from other feature properties which have values associated with each feature (element in a geopoint vector). See "Metadata and Array Assignment" on page 3-356 for usage examples.

You can attach new dynamic feature properties to the object by using dot '.' notation. This is similar to adding dynamic fields to a structure. Dynamic feature properties apply to each individual feature in the geopoint vector.

Geometry

String defining the type of geometry.

For `geopoint`, string is always `'point'`.

Attributes:

```
Geometry                    string
```

Metadata

Metadata is a scalar structure containing information for the entire set of geopoint vector elements. You can add any data type to the structure.

Attributes:

`Metadata`	`Scalar struct`

Latitude

Vector of latitude coordinates. The values can be either a row or column vector.

Attributes:

`Latitude`	`single | double vector`

Longitude

Vector of longitude coordinates. The values can be either a row or column vector.

Attributes:

`Longitude`	`single | double vector`

Dynamic properties

You can attach new properties to the object using dot `'.'` notation. The class type of the values for the dynamic properties must be either numeric, logical, char, or a cell array of strings.

Methods

append	Append features to geopoint vector
cat	Concatenate geopoint vectors
disp	Display geopoint vector
fieldnames	Dynamic properties of geopoint vector
isempty	True if `geopoint` vector is empty
isfield	Returns true if dynamic property exists

isprop	Returns true if property exists
length	Number of elements in geopoint vector
properties	Properties of a geopoint vector
rmfield	Remove dynamic property from geopoint vector
rmprop	Remove properties from geopoint vector
size	Size of `geopoint` vector
struct	Convert geopoint vector to scalar structure
vertcat	Vertical concatenation for geopoint vectors

Copy Semantics

To learn how Value classes affect copy operations, see Copying Objects.

Class Behaviors

- If the `Latitude`, `Longitude`, or a dynamic property is set with more values than features in the geopoint vector, then all other properties expand in size using 0 for numeric values and empty string for cell values.
- If the `Latitude` or `Longitude` property of the geopoint vector is set with fewer values than contained in the object, then all other properties shrink in size.
- If a dynamic property is set with fewer values than the number of features contained in the object, then this dynamic property expands to match the size of the other properties by inserting a 0 if the value is numeric or an empty string if the value is a cell array.
- If either `Latitude` or `Longitude` is set to [ ], then both coordinate properties are set to [ ] and all dynamic properties are removed.

See “Manipulate a geopoint vector” on page 3-347 for examples of these behaviors.

Examples

geopoint vector Using Latitude and Longitude Coordinates

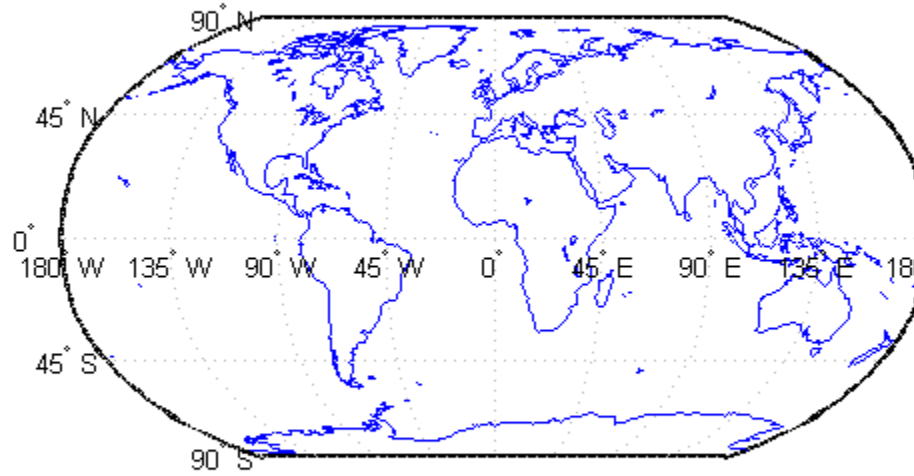
Construct a geopoint vector for one feature, and add a dynamic property

```
lat = 51.519;
lon = -.13;
p = geopoint(lat,lon);
p.Name = 'London'
```

```
p =

 1x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: 51.5190
    Longitude: -0.1300
         Name: 'London'
```

Construct a geopoint vector from a file

```
coast = load('coast');
p = geopoint(coast.lat, coast.long);
figure
worldmap world
geoshow(p.Latitude, p.Longitude)
```



geopoint vector Using a Name-Value pair

Construct a `geopoint` vector by specifying `Latitude`, `Longitude`, and `Temperature` where `Temperature` is part of a Name-Value pair.

```
point = geopoint(42, -72, 'Temperature', 89)
```

```
point =

 1x1 geopoint vector with properties:
```

```
 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
       Latitude: 42
      Longitude: -72
    Temperature: 89
```

Specify two features using Name-Value pair arguments.

```
    p = geopoint([51.519 48.871], [-.13 2.4131],...
       'Name', {'London', 'paris'})
```

```
p =

 2x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [51.5190 48.8710]
    Longitude: [-0.1300 2.4131]
         Name: {'London' 'paris'}
```

geopoint vector Using a Structure Array

Construct a `geopoint` vector from a `geostruct`.

Read in a structure containing `Lat` and `Lon` fields.

```
structArray = shaperead('worldcities', 'UseGeoCoords', true)
```

```
structArray =

318x1 struct array with fields:
    Geometry
    Lon
    Lat
```

```
    Name
```

Assign the `Lat` and `Lon` fields to coordinate properties `Latitude` and `Longitude` in the instantiated geopoint vector.

```
p = geopoint(structArray);
p(1:5)  % show first 5 entries

ans =

 5x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [5.2985 24.6525 5.6106 37.0613 9.0235]
    Longitude: [-3.9509 54.7589 -0.2121 35.3894 38.7575]
         Name: {'Abidjan' 'Abu Dhabi' 'Accra' 'Adana' 'Addis Ababa'}
```

The output displays the `'Latitude'`, `'Longitude'`, and dynamic property `'Name'` fields for the first five elements in the geopoint vector.

Add a `Filename` field to the `Metadata` structure and display it.

```
p.Metadata.Filename = 'worldcities.shp';
p.Metadata

ans =

    Filename: 'worldcities.shp'
```

`Metadata` property pertains to all elements of a geopoint vector.

geopoint vector Using Numeric Arrays and a Structure Array

```
[structArray, A] = shaperead('worldcities', 'UseGeoCoords', true)
```

```
structArray =

318x1 struct array with fields:
    Geometry
    Lon
    Lat

A =

318x1 struct array with fields:
    Name
```

Use the numeric arrays and the structure containing the list of names to construct a geopoint vector.

```
p = geopoint([structArray.Lat], [structArray.Lon], A)

p =

 318x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [1x318 double]
    Longitude: [1x318 double]
         Name: {1x318 cell}
```

Add Coordinate and Dynamic properties

An empty geopoint vector is generated from the default constructor. populate the geopoint vector by adding properties from data fields in structure `structArray` via assignment statements.

```
structArray = shaperead('worldcities', 'UseGeoCoords', true);
p = geopoint();
p.Latitude  = [structArray.Lat];
```

```
p.Longitude = [structArray.Lon];
p.Name = structArray.Name;
p

p =

 318x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [1x318 double]
    Longitude: [1x318 double]
         Name: {1x318 cell}
```

Add Vew Values to an Existing geopoint vector

Append `paderborn` data to the geopoint vector of world cities.

```
structArray = shaperead('worldcities.shp', 'UseGeoCoords', true); % re
p = geopoint(structArray);
p(end)      % display last of 318 elements in vector

ans =

 1x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: 34.8519
    Longitude: 113.8061
         Name: 'Zhengzhou'
```

Add `paderhorn` to the end of the geopoint vector and display it.

```
lat = 51.715254;  % coordiantes of paderhorn
```

```
lon = 8.75213;
p = append(p, lat, lon, 'Name', 'paderborn');
p(end-1:end)   % display penultimate and new last element

ans =

 2x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [34.8519 51.7153]
    Longitude: [113.8061 8.7521]
         Name: {'Zhengzhou' 'paderborn'}
```

You can also add a point to the end of the vector using linear indexing.

Add Arlington, Massachusetts to the end of the vector. After the initial assigment statement appends a value to the `Latitude` property vector, all other property vectors are automatically expanded by one element.

```
p(end+1).Latitude = 42.417060;  % add to end of vector
p(end).Longitude = -71.170200;  % Longitude vector already expanded
p(end).Name = 'Arlington';  % Name property also expanded
p(end-1:end)  % display penultimate and new last element

ans =

 2x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [51.7153 42.4171]
    Longitude: [8.7521 -71.1702]
         Name: {'paderborn' 'Arlington'}
```

Manipulate a geopoint vector

perform various successive operations

Construct a geopoint vector containing two features and then add two dynamic properties.

```
lat = [51.519 48.871];
lon = [-.13 2.4131];
p = geopoint(lat, lon);

p.Name = {'London', 'paris'};   % Add character feature dynamic proper
p.ID = [1 2]    % Add numeric feature dynamic property
```

```
p =

 2x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [51.5190 48.8710]
    Longitude: [-0.1300 2.4131]
         Name: {'London' 'paris'}
           ID: [1 2]
```

Add the coordinates for a third feature.

```
p(3).Latitude = 45.472;
p(3).Longitude = 9.184
```

```
p =

 3x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
```

```
    Metadata: [1x1 struct]
Feature properties:
    Latitude: [51.5190 48.8710 45.4720]
   Longitude: [-0.1300 2.4131 9.1840]
        Name: {'London' 'paris' ''}
          ID: [1 2 0]
```

Note that lengths of all feature properties are synchronized with default values.

Set the values for the `ID` feature dynamic property with more values than contained in `Latitude` or `Longitude`.

```
p.ID = 1:4
```

```
p =

 4x1 geopoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
    Latitude: [51.5190 48.8710 45.4720 0]
   Longitude: [-0.1300 2.4131 9.1840 0]
        Name: {'London' 'paris' '' ''}
          ID: [1 2 3 4]
```

Note that all feature properties are expanded to match in size.

Set the values for the ID feature dynamic property with fewer values than contained in the `Latitude` or `Longitude` properties.

```
p.ID = 1:2
```

```
p =

 4x1 geopoint vector with properties:
```

```
 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [51.5190 48.8710 45.4720 0]
    Longitude: [-0.1300 2.4131 9.1840 0]
         Name: {'London' 'paris' '' ''}
           ID: [1 2 0 0]
```

The `ID` property values expand to match the length of the `Latitude` and `Longitude` property values.

Set the value of either coordinate property (`Latitude` or `Longitude`) with fewer values.

```
p.Latitude = [51.519 48.871]
```

```
p =

 2x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [51.5190 48.8710]
    Longitude: [-0.1300 2.4131]
         Name: {'London' 'paris'}
           ID: [1 2]
```

All properties shrink to match in size.

Remove the `ID` property by setting its value to [ ].

```
p.ID = []
```

```
p =
```

```
 2x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [51.5190 48.8710]
    Longitude: [-0.1300 2.4131]
         Name: {'London' 'paris'}
```

Remove all dynamic properties and set the object to empty by setting a coordinate property value to [ ].

```
p.Latitude = []

p =

 0x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: []
    Longitude: []
```

Sort dynamic properties and Extract subsets

Sorting dynamic properties

Data is read in from the file. Initially the field names of the class are in random order.

```
structArray = shaperead('tsunamis', 'UseGeoCoords', true); % Field names
p = geopoint(structArray)

p =
```

```
 162x1 geopoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
       Latitude: [1x162 double]
      Longitude: [1x162 double]
           Year: [1x162 double]
          Month: [1x162 double]
            Day: [1x162 double]
           Hour: [1x162 double]
         Minute: [1x162 double]
         Second: [1x162 double]
       Val_Code: [1x162 double]
       Validity: {1x162 cell}
     Cause_Code: [1x162 double]
          Cause: {1x162 cell}
         Eq_Mag: [1x162 double]
        Country: {1x162 cell}
       Location: {1x162 cell}
     Max_Height: [1x162 double]
       Iida_Mag: [1x162 double]
      Intensity: [1x162 double]
     Num_Deaths: [1x162 double]
    Desc_Deaths: [1x162 double
```

Using the method `fieldnames` and typical MATLAB vector notation, the field names in the geopoint vector are alphabetically sorted.

```
p = p(:, sort(fieldnames(p)))

p =

 162x1 geopoint vector with properties:

 Collection properties:
```

```
      Geometry: 'point'
      Metadata: [1x1 struct]
Feature properties:
      Latitude: [1x162 double]
     Longitude: [1x162 double]
         Cause: {1x162 cell}
    Cause_Code: [1x162 double]
       Country: {1x162 cell}
           Day: [1x162 double]
   Desc_Deaths: [1x162 double]
        Eq_Mag: [1x162 double]
          Hour: [1x162 double]
      Iida_Mag: [1x162 double]
     Intensity: [1x162 double]
      Location: {1x162 cell}
    Max_Height: [1x162 double]
        Minute: [1x162 double]
         Month: [1x162 double]
    Num_Deaths: [1x162 double]
        Second: [1x162 double]
      Val_Code: [1x162 double]
      Validity: {1x162 cell}
          Year: [1x162 double]
```

Extract a subset of properties

Using typical MATLAB vector notation, a subset of data can be extracted from the base geopoint vector and is itself a geopoint vector albeit smaller in size.

```
subp = p(20:40,{'Location','Country','Year'}) % get subset of data

subp =

 21x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
```

```
    Metadata: [1x1 struct]
 Feature properties:
    Latitude: [1x21 double]
   Longitude: [1x21 double]
    Location: {1x21 cell}
     Country: {1x21 cell}
        Year: [1x21 double]
```

Note that the coordinate properties, `Latitude` and `Longitude`, as well as the collection properties are retained in this subset of geopoint vectors.

Work with property Values

Set, get, and remove dynamic property values from a geopoint vector.

To set property values, use the `()` operator, or assign array values to corresponding fields, or use dot `'.'` notation (object.property) to assign new property values.

Assign arrays to fields

```
pts = geopoint();
pts.Latitude = [42 44 45];
pts.Longitude = [-72 -72.1 -71];
pts
```

```
pts =

 3x1 geopoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
    Latitude: [42 44 45]
   Longitude: [-72 -72.1000 -71]
```

Use ( ) to assign values to fields.

```
pts(3).Latitude = 45.5;
pts
```

```
pts =

 3x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [42 44 45.5000]
    Longitude: [-72 -72.1000 -71]
```

Use dot notation to create new dynamic properties

```
pts.Name = {'point1', 'point2', 'point3'}
```

```
pts =

 3x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [42 44 45.5000]
    Longitude: [-72 -72.1000 -71]
         Name: {'point1' 'point2' 'point3'}
```

Get property values

```
pts.Name
```

```
ans =
```

```
    'point1'    'point2'    'point3'
```

Remove dynamic properties

To delete or remove dynamic properties, set them to `[]` or set the `Latitude` or `Longitude` property to `[]`.

```
pts.Temperature = 1:3

pts =

 3x1 geopoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
       Latitude: [42 44 45.5000]
      Longitude: [-72 -72.1000 -71]
           Name: {'point1' 'point2' 'point3'}
    Temperature: [1 2 3]
```

By setting the `Temperature` property to `[]`, this dynamic property is deleted.

```
pts.Temperature = []

pts =

 3x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [42 44 45.5000]
    Longitude: [-72 -72.1000 -71]
```

```
        Name: {'point1' 'point2' 'point3'}
```

To clear all fields in the `geopoint` vector, set the `Latitude` or `Longitude` property to `[]`

```
pts.Latitude = []

pts =

 0x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: []
    Longitude: []
```

Metadata and Array Assignment

Modify a `geopoint` object and its metadata.

If you typically store latitude and longitude coordinates in an `N-by-2` or `2 by-M` array, you can assign these numeric values to a `geopoint` vector. If the coordinates are `N-by-2`, then the first column is assigned to the `Latitude` property and the second column to the `Longitude` property. If the coordinates are `2-by-M`, then the first row is assigned to the `Latitude` property and the second row to the `Longitude` property.

```
coast = load('coast');
ltln = [coast.lat coast.long];  % 9865x2 array
pts = geopoint;   % null constructor
pts(1:numel(coast.lat)) = ltln;  % assign array
pts.Metadata.Name = 'coastline';
pts
pts.Metadata

pts =
```

```
 9865x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [1x9865 double]
    Longitude: [1x9865 double]


ans =

    Name: 'coastline'
```

See Also

gpxread | shaperead | mappoint | geoshape | mapshape

geopoint.append

Purpose

Append features to geopoint vector

Syntax

```
P = append(P,lat,lon)
P = append(P,lat,lon,Name,Value)
```

Description

`P = append(P,lat,lon)` appends the latitude values in the numeric array, `lat` to the `Latitude` property of the geopoint vector, `P`, and the longitude values in the numeric array, `lon`, to the `Longitude` property of `P`.

`P = append(P,lat,lon,Name,Value)` appends `lat` and `lon` values to the geopoint vector. The method adds dynamic properties to the object using `Name` for the names of the dynamic properties, and then assign `Value` to them.

Input Arguments

`P`

geopoint vector.

`lat`

Numeric vector of `Latitude` values.

`lon`

Numeric vector of `Longitude` values.

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

`Name,Value`

Parameter Name-Value pairs of the dynamic properties that are to be added to the geopoint vector, `P`.

Output Arguments

P

Modified geopoint vector with additional entries in `Latitude` and `Longitude` fields along with any new fields for dynamic properties that you added.

Examples

Append Values to Fields in a geopoint Vector

Append values to existing fields of a geopoint vector.

```
P = geopoint(42,-110, 'Temperature', 65);
P = append(P, 42.1, -110.4, 'Temperature', 65.5)

P =

 2x1 geopoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
       Latitude: [42 42.1000]
      Longitude: [-110 -110.4000]
    Temperature: [65 65.5000]
```

Append Dynamic Property to a geopoint Vector

Append dynamic property, `'Pressure'`, to a geopoint vector.

```
P = geopoint(42,-110, 'Temperature', 65);
P = append(P, 42.2, -110.5, 'Temperature', 65.6, 'Pressure', 100.0)

P =

 2x1 geopoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
```

```
 Feature properties:
       Latitude: [42 42.2000]
      Longitude: [-110 -110.5000]
    Temperature: [65 65.6000]
       Pressure: [0 100]
```

See Also

geopoint | geopoint.vertcat |

Purpose

Concatenate geopoint vectors

Syntax

```
P= cat(dim,P1, P2, ...)
```

Description

`P= cat(dim,P1, P2, ...)` concatenates the geopoint vectors `P1`,`P2` and so on along dimensions `dim`. `dim` must be `1`.

Input Arguments

`P1, P2, ...`

geopoint vectors to be concatenated.

Output Arguments

`P`

Concatenated geopoint vector.

Examples

Concatenate two geopoint vectors

Create two geopoint vectors and concatenate them to a single vector.

```
pt1 = geopoint(42,-110, 'Temperature', 65);
pt2 = geopoint(42.2, -110.5, 'Temperature', 65.6);
p = cat(1,pt1,pt2)
```

```
p =

 2x1 geopoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
       Latitude: [42 42.2000]
      Longitude: [-110 -110.5000]
    Temperature: [65 65.6000]
```

See Also

`geopoint.vertcat` |

geopoint.disp

Purpose

Display geopoint vector

Syntax

```
disp(P)
```

Description

`disp(P)` prints the size of the geopoint vector, `P`, and its properties and dynamic properties, if they exist. If the command window is large enough, the values of the properties are also shown, otherwise only their size is shown. You can control the display of the numerical values by using the format command.

Input Arguments

`P`

geopoint vector.

Examples

Display a geopoint vector

Display a geopoint vector.

```
p = geopoint(shaperead('worldcities', 'UseGeo', true));
disp(p)
disp(p(1:2))
```

```
 318x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [1x318 double]
    Longitude: [1x318 double]
         Name: {1x318 cell}

 2x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
```

```
     Latitude: [5.2985 24.6525]
    Longitude: [-3.9509 54.7589]
         Name: {'Abidjan' 'Abu Dhabi'}
```

See Also

formatgeopoint |

geopoint.fieldnames

Purpose

Dynamic properties of geopoint vector

Syntax

```
names = fieldnames(P)
```

Description

`names = fieldnames(P)` returns the names of the dynamic properties of the geopoint vector, `P`.

Input Arguments

`P`

geopoint vector for which the properties are to be queried.

Output Arguments

`names`

Names of the dynamic properties in the geopoint vector `P`

Examples

Find dynamic properties

Return the dynamic properties of a geopoint vector

```
P = geopoint(shaperead('worldcities', 'UseGeo', true));
fieldnames(P)
```

```
ans =

    'Name'
```

See Also

`geopoint.properties` |

Purpose

True if `geopoint` vector is empty

Syntax

```
TF = isempty(P)
```

Description

`TF = isempty(P)` returns true if the geopoint vector, `P`, is empty and false otherwise.

Input Arguments

`P`

geopoint vector.

Examples

Check if a geopoint vector is empty

Check if the geopoint vector is empty.

```
P = geopoint();
isempty(P)
```

```
ans =

     1
```

See Also

`geopoint.end` |

geopoint.isfield

Purpose

Returns true if dynamic property exists

Syntax

```
TF = isfield(P,name)
TF = isfield(P,names)
```

Description

`TF = isfield(P,name)` returns true if the value specified by the string `name` is a dynamic property of the geopoint vector, `P`.

`TF = isfield(P,names)` return true for each element of the cell array, `names`, that is a dynamic property of `P`. `TF` is a logical array of the same size as `names`.

Input Arguments

P

geopoint vector.

name

Name of the dynamic property.

names

Cell array of names of dynamic properties.

Output Arguments

TF

`Boolean`. 1 if `P` contains the specified fields or 0 otherwise.

Examples

Check for fieldname

Check if a field is present in a geopoint vector.

```
p = geopoint(-33.961, 18.484, 'Name', 'Cape Town');
isfield(p, 'Latitude')
isfield(p, 'Name')
```

```
ans =

     0
```

```
ans =

     1
```

See Also

geopoint.isprop | geopoint.fieldnames |

geopoint.isprop

Purpose

Returns true if property exists

Syntax

```
TF = isprop(P,name)
TF = isprop(P,names)
```

Description

`TF = isprop(P,name)` returns true if the value specified by the string, `name` is a property of the geopoint vector, `P`.

`TF = isprop(P,names)` returns true for each element of the cell array of strings, `names`, that is a property of `P`. `TF` is a logical array the same size as `names`.

Input Arguments

`P`

geopoint vector.

`name`

String specifying the property of the geopoint vector, `P`.

`names`

Cell array of strings specifying the property of the geopoint vector, `P`.

Output Arguments

`TF`

Boolean. 1 if the property exists with `P` ,0 otherwise.

Examples

Check if property exists

This example shows how to check if a string is a property of a geopoint vector.

```
p = geopoint(-33.961, 18.484, 'Name', 'Cape Town');
isprop(p, 'Latitude')
isprop(p, 'Name')
```

```
ans =

     1
```

```
ans =

     1
```

See Also

geopoint.isfield | geopoint.properties |

geopoint.length

Purpose

Number of elements in geopoint vector

Syntax

```
N = length(P)
```

Description

`N = length(P)` returns the number of elements contained in the geopoint vector, `P`. The result is equivalent to `size(P,1)`.

Input Arguments

P

geopoint vector.

Output Arguments

N

Length of the geopoint vector, P.

Examples

Find the length of the geopoint vector.

```
coast = load('coast');
p = geopoint(coast.lat, coast.long);
length(p)
length(coast.lat)
```

```
ans =

        9865


ans =

        9865
```

See Also

`geopoint.size` |

Purpose

Properties of a geopoint vector

Syntax

```
prop = properties(P)
properties(P)
```

Description

`prop = properties(P)` returns a cell of the property names of the geopoint vector, `P`.

`properties(P)` displays the names of the properties of `P`.

Input Arguments

`P`

geopoint vector.

Output Arguments

`prop`

Cell variable consisting of property names of the geopoint vector, `P`.

Examples

Properties of a geopoint vector

Query for properties of a geopoint vector.

```
p = geopoint(shaperead('tsunamis', 'UseGeo', true));
properties(p)
```

```
Properties for class geopoint:

    Geometry
    Metadata
    Latitude
    Longitude
    Year
    Month
    Day
    Hour
    Minute
    Second
```

```
    Val_Code
    Validity
    Cause_Code
    Cause
    Eq_Mag
    Country
    Location
    Max_Height
    Iida_Mag
    Intensity
    Num_Deaths
    Desc_Deaths
```

See Also `geopoint.fieldnames` |

Purpose

Remove dynamic property from geopoint vector

Syntax

```
P = rmfield(P, fieldname)
P = rmfield(P, fields)
```

Description

`P = rmfield(P, fieldname)` removes the field specified by the string, `fieldname` , from the geopoint vector, `P`.

`P = rmfield(P, fields)` removes all the fields specified by the cell array, `fields`.

Note `rmfield` cannot remove `Latitude`, `Longitude` and `Metadata` fields and the string specified is case sensitive.

Input Arguments

P

geopoint vector.

fieldname

Exact string representing the name of the property.

fields

Cell array of strings specifying the names of the properties.

Output Arguments

P

Updated geopoint vector with the field(s) removed.

Examples

Remove fields from a geopoint vector

Remove fields from a geopoint vector.

```
p = geopoint(shaperead('tsunamis', 'UseGeo', true));
p2 = rmfield(p, 'Geometry')
```

```
p2 =
```

```
162x1 geopoint vector with properties:

Collection properties:
      Geometry: 'point'
      Metadata: [1x1 struct]
Feature properties:
      Latitude: [1x162 double]
     Longitude: [1x162 double]
          Year: [1x162 double]
         Month: [1x162 double]
           Day: [1x162 double]
          Hour: [1x162 double]
        Minute: [1x162 double]
        Second: [1x162 double]
      Val_Code: [1x162 double]
      Validity: {1x162 cell}
    Cause_Code: [1x162 double]
         Cause: {1x162 cell}
        Eq_Mag: [1x162 double]
       Country: {1x162 cell}
      Location: {1x162 cell}
    Max_Height: [1x162 double]
      Iida_Mag: [1x162 double]
     Intensity: [1x162 double]
    Num_Deaths: [1x162 double]
   Desc_Deaths: [1x162 double]
```

See Also

geopoint.fieldnames | geopoint.rmprop |

Purpose

Remove properties from geopoint vector

Syntax

```
PF = rmprop(P,propname)
PF = rmprop(P,propnames)
```

Description

`PF = rmprop(P,propname)` removes the property specified by the string, `propname` from the geopoint vector, `P`.

`PF = rmprop(P,propnames)` removes all the properties specified in the cell array, `propnames`, from the geopoint vector, `P`. If `propnames` contains a coordinate property an error is issued.

Note `rmprop` cannot remove `Latitude`, `Longitude` and `Metadata` fields and the string specified is case sensitive.

Input Arguments

`P`

geopoint vector.

Output Arguments

`PF`

Modified geopoint vector with the specified property(s) removed.

Examples

Remove a property of a geopoint vector

Remove a property from a geopoint vector.

```
p = geopoint(shaperead('tsunamis', 'UseGeo', true));
p2 = rmprop(p, 'Validity')
```

```
p2 =

 162x1 geopoint vector with properties:

 Collection properties:
       Geometry: 'point'
```

```
      Metadata: [1x1 struct]
Feature properties:
      Latitude: [1x162 double]
     Longitude: [1x162 double]
          Year: [1x162 double]
         Month: [1x162 double]
           Day: [1x162 double]
          Hour: [1x162 double]
        Minute: [1x162 double]
        Second: [1x162 double]
      Val_Code: [1x162 double]
    Cause_Code: [1x162 double]
         Cause: {1x162 cell}
        Eq_Mag: [1x162 double]
       Country: {1x162 cell}
      Location: {1x162 cell}
    Max_Height: [1x162 double]
      Iida_Mag: [1x162 double]
     Intensity: [1x162 double]
    Num_Deaths: [1x162 double]
   Desc_Deaths: [1x162 double]
```

See Also `geopoint.fieldnames` |

Purpose

Size of `geopoint` vector

Syntax

```
SZ = size(P)
SZ = size(P,1)
SZ = size(P, n)
[m,k] = size(P)
```

Description

`SZ = size(P)` returns the vector `[length(P), 1]`.

`SZ = size(P,1)` returns the length of `P`.

`SZ = size(P, n)` returns `1` for `n >= 2`.

`[m,k] = size(P)` returns `length(P)` for `m` and `1` for `k`.

Input Arguments

`P`

geopoint vector.

`n`

Number of the dimension at which size of `P` is required.

Output Arguments

`SZ`

Vector of the form `[length(P), 1]`.

`m`

Length of `P`.

`k`

Length of second dimension of `P`. `k` is always `1`.

Examples

Size of a geopoint vector

Find the size of a geopoint vector.

```
coast = load('coast');
p = geopoint(coast.lat, coast.long);
size(p)
```

```
ans =

        9865           1
```

The second dimension is always 1.

See Also

`geopoint.length` | `size`

Purpose

Convert geopoint vector to scalar structure

Syntax

```
S = struct(P)
```

Description

`S = struct(P)` converts the geopoint vector, `P`, to a scalar structure, `S`.

Input Arguments

`P`

geopoint vector.

Output Arguments

`S`

Scalar structure of the geopoint vector `P`.

Examples

Converting a geopoint vector into struct

This example shows how to convert a geopoint vector to `struct`.

```
S = shaperead('worldcities', 'UseGeo', true);
p = geopoint(S)
S2 = struct(p)
class(S2)
```

```
p =

 318x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [1x318 double]
    Longitude: [1x318 double]
         Name: {1x318 cell}


S2 =
```

```
     Geometry: 'point'
     Metadata: [1x1 struct]
     Latitude: [1x318 double]
    Longitude: [1x318 double]
         Name: {1x318 cell}


ans =

struct
```

See Also geopoint.properties |

Purpose

Vertical concatenation for geopoint vectors

Syntax

```
P = vertcat(P1,P2, ...)
```

Description

`P = vertcat(P1,P2, ...)` vertically concatenates the geopoint vector, `P1, P2,` and so on. If the class type of any property is a cell array, then the resultant field in the output `P` will also be a cell array.

Input Arguments

`P1, P2, ...`

geopoint vectors that need to be concatenated.

Output Arguments

`P`

Concatenated geopoint vector.

Examples

Concatenate geopoint vectors

Concatenate two geopoint vectors.

```
pt1 = geopoint(42, -110, 'Temperature', 65, 'Name', 'point1');
pt2 = geopoint( 42.1, -110.4, 'Temperature', 65.5, 'Name', 'point2');
pts = vertcat(pt1, pt2)
```

```
pts =

 2x1 geopoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
       Latitude: [42 42.1000]
      Longitude: [-110 -110.4000]
    Temperature: [65 65.5000]
           Name: {'point1' 'point2'}
```

See Also

`geopoint.cat` |

geoquadline

Purpose

Geographic quadrangle bounding multi-part line

Syntax

```
[latlim,lonlim] = geoquadline(lat,lon)
```

Description

`[latlim,lonlim] = geoquadline(lat,lon)` returns the limits of the tightest possible geographic quadrangle that bounds a line connecting vertices with geographic coordinates specified by `lat` and `lon`.

Input Arguments

lat - Latitudes along a line

vector

Latitudes along a line, specified as a vector representing an ordered sequences of vertices, in units of degrees. The line may be broken into multiple parts, delimited by values of `NaN`.

Data Types
single | double

lon - Longitudes along a line

vector

Longitudes along a line, specified as a vector representing an ordered sequences of vertices, in units of degrees. The line may be broken into multiple parts, delimited by values of `NaN`.

Data Types
single | double

Output Arguments

latlim - Latitude limits

1–by-2 vector

Latitude limits of a geographic quadrangle, returned as a 1-by-2 vector of the form `[southern_limit northern_limit]`, in units of degrees. The elements are in ascending order, and both lie in the closed interval [-90 90].

lonlim - Latitude limits

1–by-2 vector

Longitude limits of a geographic quadrangle, returned as a 1-by-2 vector of the form `[western_limit eastern_limit]`, in units of degrees. The limits are wrapped to the interval [-180 180]. They are not necessarily in numerical ascending order.

Examples

Bounding Quadrangle for the Brahmaputra River.

```
brahmaputra = shaperead('worldrivers.shp','Selector',{@(name) strcmp(n
[latlim, lonlim] = geoquadline(brahmaputra.Lat, brahmaputra.Lon)
```

```
latlim =

   23.8285   30.3831


lonlim =

   81.8971   95.4970
```

See Also

`bufgeoquad` | `geoquadpt` | `outlinegeoquad` | `ingeoquad`

geoquadpt

Purpose

Geographic quadrangle bounding scattered points

Syntax

```
[latlim,lonlim] = geoquadpt(lat,lon)
```

Description

`[latlim,lonlim] = geoquadpt(lat,lon)` returns the limits of the tightest possible geographic quadrangle that bounds a set of points with geographic coordinates `lat` and `lon`.

In most cases, `tf` = `ingeoquad`(`lat`,`lon`,`latlim`,`lonlim`) will return true, but `tf` may be false for points on the edges of the quadrangle, due to round off. `tf` will also be false for elements of `lat` that fall outside the interval [-90 90] and elements of `lon` that are not finite.

Input Arguments

lat - Point latitudes

vector | matrix | N-D array

Point latitudes, specified as a vector, matrix, or N-D array, in units of degrees.

Data Types
single | double

lon - Point longitudes

vector | matrix | N-D array

Point longitudes, specified as a vector, matrix, or N-D array, in units of degrees.

Data Types
single | double

Output Arguments

latlim - Latitude limits

1–by-2 vector

Latitude limits of a geographic quadrangle, returned as a 1-by-2 vector of the form `[southern_limit northern_limit]`, in units of degrees. The elements are in ascending order, and both lie in the closed interval [-90 90].

lonlim - Latitude limits

1–by-2 vector

Longitude limits of a geographic quadrangle, returned as a 1-by-2 vector of the form `[western_limit eastern_limit]`, in units of degrees. The limits are wrapped to the interval [-180 180]. They are not necessarily in numerical ascending order.

Examples

Bounding Quadrangle Including Tokyo and Honolulu.

In this case the output quadrangle straddles the 180-degree meridian, hence the elements of lonlim are in descending numerical order, although they are ordered from west to east.

```
cities = shaperead('worldcities.shp','Selector',{@(name) any(strcmp(na
[latlim,lonlim] = geoquadpt([cities.Lat],[cities.Lon])

latlim =

   21.3178   35.7082


lonlim =

  139.6401 -157.8291
```

See Also

`bufgeoquad` | `geoquadline` | `outlinegeoquad` | `ingeoquad`

georasterref

Purpose

Construct `spatialref.GeoRasterReference` object

Syntax

```
R = georasterref()
R = georasterref(Name,Value)
R = georasterref(W, rasterSize, rasterInterpretation)
```

Description

`R = georasterref()` constructs a `spatialref.GeoRasterReference` object with default property values.

`R = georasterref(Name,Value)` accepts a list of name-value pairs that are used to assign selected properties when initializing a `spatialref.GeoRasterReference` object.

`R = georasterref(W, rasterSize, rasterInterpretation)` constructs a `spatialref.GeoRasterReference` object with the specified raster size and interpretation properties, and with remaining properties defined by `W`.

Input Arguments

W

2-by-3 world file matrix

rasterSize

Two-element vector `[M N]` specifying the number of rows (*M*) and columns (*N*) of the raster or image associated with the referencing object. For convenience, you may assign a size vector having more than two elements to `RasterSize`. This flexibility enables assignments like `R.RasterSize = size(RGB)`, for example, where `RGB` is *M*-by-*N*-by-3. However, in such cases, only the first two elements of the size vector are actually stored. The higher (non-spatial) dimensions are ignored.

rasterInterpretation

Controls handling of raster edges. The `rasterInterpretation` input is optional, and can equal either `'cells'` or `'postings'`.

Default: `'cells'`

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

You can include any of the following properties, overriding their default values as needed. Alternatively, you may omit any or all properties when constructing your `spatialref.GeoRasterReference` object. Then, you can customize the result by resetting properties from this list one at a time.

Latlim

Limits in latitude of the geographic quadrangle bounding the georeferenced raster. A two-element vector of the form:

```
[southern_limit northern_limit]
```

Default: [0.5 2.5]

Lonlim

Limits in longitude of the geographic quadrangle bounding the georeferenced raster. A two-element vector of the form:

```
[western_limit eastern_limit]
```

Default: [0.5 2.5]

RasterSize

Two-element vector `[M N]` specifying the number of rows (*M*) and columns (*N*) of the raster or image associated with the referencing object. For convenience, you may assign a size vector having more than two elements to `RasterSize`. This flexibility enables assignments like `R.RasterSize = size(RGB)`, for example, where `RGB` is *M*-by-*N*-by-3.

However, in such cases, only the first two elements of the size vector are actually stored. The higher (non-spatial) dimensions are ignored.

Default: [2 2]

RasterInterpretation

Controls handling of raster edges. A string that equals either `'cells'` or `'postings'`.

Default: `'cells'`

ColumnsStartFrom

Edge from which column indexing starts. A string that equals either `'south'` or `'north'`.

Default: `'south'`

RowsStartFrom

Edge from which row indexing starts. A string that equals either `'west'` or `'east'`.

Default: `'west'`

Output Arguments

R

`spatialref.GeoRasterReference` object

Examples

Construct a referencing object for a global raster comprising 180-by-360 one-degree cells, with rows that start at longitude –180, and with the first cell located in the northwest corner.

```
% Override the default MATLAB display format.
% This is not strictly required, but tends to produce
% the most readable displays.
format short g
```

```
% Construct a spatialref.GeoRasterReference object.
R = georasterref('RasterSize', [180 360], ...
       'RasterInterpretation', 'cells', ...
       'Latlim', [-90 90], 'Lonlim', [-180 180], ...
       'ColumnsStartFrom', 'north')
```

Construct a referencing object for the DTED Level 0 file that includes Sagarmatha (Mount Everest). The DTED columns run from south to north and the first column runs along the western edge of the (one-degree-by-one-degree) quadrangle, consistent with the default values for `'ColumnsStartFrom'` and `'RowsStartFrom'`.

```
R = georasterref('Latlim', [27 28], 'Lonlim', [86 87], ...
       'RasterSize', [121 121], ...
       'RasterInterpretation', 'postings')
```

Repeat the second example with a different strategy: Create a default object and then modify that object's properties as needed.

```
R = georasterref;
R.RasterSize = [121 121];
R.RasterInterpretation = 'postings';
R.Latlim = [27 28];
R.Lonlim = [86 87]
```

Repeat the first example using a world file matrix as input.

```
W = [1    0   -179.5; ...
     0   -1     89.5];
rasterSize = [180 360];
rasterInterpretation = 'cells';
R = georasterref(W, rasterSize, rasterInterpretation);
```

See Also

`maprasterref` | `spatialref.GeoRasterReference`

spatialref.GeoRasterReference

Purpose

Reference raster to geographic coordinates

Description

A `spatialref.GeoRasterReference` object encapsulates the relationship between a geographic coordinate system and a system of *intrinsic coordinates* anchored to the columns and rows of a 2-D spatially referenced raster grid or image. The raster must be sampled regularly in latitude and longitude, and its columns and rows must be aligned with meridians and parallels, respectively.

Construction

Construct a `GeoRasterReference` object using either the:

- `georasterref` function (recommended)
- `spatialref.GeoRasterReference` class constructor
- `refvecToGeoRasterReference` or `refmatToGeoRasterReference` conversion functions if you already have an equivalent referencing vector or matrix

When invoked with no input argument, both `georasterref` and the class constructor construct an object with these default property settings:

```
                  Latlim: [0.5 2.5]
                  Lonlim: [0.5 2.5]
              RasterSize: [2 2]
    RasterInterpretation: 'cells'
              AngleUnits: 'degrees'
        ColumnsStartFrom: 'south'
           RowsStartFrom: 'west'
                DeltaLat: 1
                DeltaLon: 1
  RasterExtentInLatitude: 1
 RasterExtentInLongitude: 1
           XLimIntrinsic: [0.5 2.5]
           YLimIntrinsic: [0.5 2.5]
   CoordinateSystemType: 'geographic'
```

Properties

Latlim

Latitude limits of the geographic quadrangle bounding the georeferenced raster. A two-element vector of the form:

```
[southern_limit northern_limit]
```

Default: `[0.5 2.5]`

Lonlim

Longitude limits of the geographic quadrangle bounding the georeferenced raster. A two-element vector of the form:

```
[western_limit eastern_limit]
```

Default: `[0.5 2.5]`

RasterSize

Two-element vector `[M N]` specifying the number of rows (*M*) and columns (*N*) of the raster or image associated with the referencing object. For convenience, you can assign a size vector having more than two elements to `RasterSize`. This enables assignments like `R.RasterSize = size(RGB)`, where `RGB` is *M*-by-*N*-by-3. In cases like this, only the first two elements of the size vector are stored. Higher (nonspatial) dimensions are ignored. *M* and *N* must be positive in all cases and must be 2 or greater when `RasterInterpretation` is `'postings'`.

Default: `[2 2]`

RasterInterpretation

Controls handling of raster edges. A string that equals `'cells'` or `'postings'`.

Default: `'cells'`

AngleUnits

Unit of angle used for angle-valued properties. A string that equals `'degrees'`.

ColumnsStartFrom

Edge from which column indexing starts. A string that equals `'south'` or `'north'`.

Default: `'south'`

RowsStartFrom

Edge from which row indexing starts. A string that equals `'west'` or `'east'`.

Default: `'west'`

DeltaLat

Change in latitude with respect to intrinsic *y*. Amount by which latitude increases or decreases with respect to an increase of one unit in intrinsic *y*. Positive when columns start from south, and negative when columns start from north. Its absolute value equals the latitude extent of a single cell, when `RasterInterpretation` is `'cells'`, or the latitude separation of adjacent sample points, when `RasterInterpretation` is `'postings'`).

Cannot be set.

DeltaLon

Change in longitude with respect to intrinsic *x*. Amount by which longitude increases or decreases with respect to an increase of one unit in intrinsic *x*. Positive when rows start from west, and negative when rows start from east. Its absolute value equals the longitude extent of a single cell, when `RasterInterpretation` is `'cells'`, or the longitude separation of adjacent sample points, when `RasterInterpretation` is `'postings'`.

Cannot be set.

RasterExtentInLatitude

Latitude extent ("height") of the quadrangle covered by the raster.

Cannot be set.

RasterExtentInLongitude

Longitude extent ("width") of the quadrangle covered by the raster.

Cannot be set.

XLimIntrinsic

Raster limits in intrinsic *x*. A two-element row vector `[xMin xMax]`. For an *M*-by-*N* raster with `RasterInterpretation` equal to `'postings'`, it equals `[1 N]`; and for `'cells'`, it equals `[0.5, N + 0.5]`.

Cannot be set.

YLimIntrinsic

Raster limits in intrinsic *y*. A two-element row vector `[yMin yMax]`. For an *M*-by-*N* raster with `RasterInterpretation` equal to `'postings'`, it equals `[1 M]`; and for `'cells'`, it equals `[0.5, M + 0.5]`.

Cannot be set.

CoordinateSystemType

Type of coordinate system to which the image or raster is referenced. A constant string with value `'geographic'`.

Methods

contains	True if raster contains latitude-longitude points
geographicToIntrinsic	Convert from geographic to intrinsic coordinates

geographicToSub	Geographic coordinates to row and column subscripts
intrinsicToGeographic	Convert from intrinsic to geographic coordinates
intrinsicXToLongitude	Convert from intrinsic *x* to longitude
intrinsicYToLatitude	Convert from intrinsic *y* to latitude
latitudeToIntrinsicY	Convert from latitude to intrinsic *y*
longitudeToIntrinsicX	Convert from longitude to intrinsic *x*
sizesMatch	True if object and raster or image are size compatible
worldFileMatrix	World file parameters for transformation

Definitions

Intrinsic Coordinate System

A 2-D Cartesian system with its *x*-axis running parallel to the rows of a raster or image and its *y*-axis running parallel to the columns. *x* increases by 1 from column to column, and *y* increases by 1 from row to row.

Mapping Toolbox and Image Processing Toolbox™ use the convention for the location of the origin relative to the raster cells or sampling points such that, at a sample location or at the center of a cell, *x* has an integer value equal to the column index. Likewise, at a sample location or at the center of a cell, *y* has an integer value equal to the row index. For details, see Image Coordinate Systems in the Image Processing Toolbox documentation.

Examples

Construct a `spatialref.GeoRasterReference` object and specify some properties:

```
R = spatialref.GeoRasterReference;
R.RasterSize = [180 360];
R.Latlim = [-90 90];
R.Lonlim = [-180 180];
R.ColumnsStartFrom = 'north'
```

You can also specify inputs in the call to the constructor. To see examples of this advanced syntax, at the command line type:

```
help spatialref.GeoRasterReference/GeoRasterReference
```

See Also

`georasterref` | `refmatToGeoRasterReference` | `refvecToGeoRasterReference` | `spatialref.MapRasterReference`

spatialref.GeoRasterReference.contains

Purpose

True if raster contains latitude-longitude points

Syntax

```
TF = R.contains(lat,lon)
```

Description

`TF = R.contains(lat,lon)` returns a logical array `TF` having the same size as `lat` and `lon` such that `TF(k)` is `true` if and only if the point `(lat(k),lon(k))` falls within the bounds of the raster associated with referencing object `R`. Elements of `lon` can be wrapped arbitrarily without affecting the result.

Purpose

Convert from geographic to intrinsic coordinates

Syntax

```
[xIntrinsic, yIntrinsic] = R.geographicToIntrinsic(lat, lon)
```

Description

`[xIntrinsic, yIntrinsic] = R.geographicToIntrinsic(lat, lon)` returns the intrinsic coordinates `(xIntrinsic, yIntrinsic)` of a set of points given their geographic coordinates `(lat, lon)`, based on the relationship defined by referencing object `R`. `lat` and `lon` must have the same size, and all (non-NaN) elements of `lat` must fall within the interval `[-90 90]` degrees. `xIntrinsic` and `yIntrinsic` have the same size as `lat` and `lon`. The input can include points outside the geographic quadrangle bounding the raster. As long as their latitudes are valid, the locations of such points are extrapolated outside the bounds of the raster in the intrinsic coordinate system.

spatialref.GeoRasterReference.geographicToSub

Purpose

Geographic coordinates to row and column subscripts

Syntax

```
[I,J] = R.geographicToSub(lat,lon)
```

Description

`[I,J] = R.geographicToSub(lat,lon)` returns subscript arrays `I` and `J`. When referencing object `R` has `RasterInterpretation` `'cells'`, these are the row and column subscripts of the raster cells (or image pixels) containing each element of a set of points given their geographic coordinates `(lat, lon)`. If `R.RasterInterpretation` is `'postings'`, then the subscripts refer to the nearest sample point (posting).

`lat` and `lon` must have the same size. `I` and `J` will have the same size as `lat` and `lon`. For an *M*-by-*N* raster, `1 <= I <= M` and `1 <= J <= N`, except when a point `lat(k),lon(k)` falls outside the image, as defined by `R.contains(lat,lon)`. Then both `I(k)` and `J(k)` are NaN.

Purpose

Convert from intrinsic to geographic coordinates

Syntax

```
[lat, lon] = R.intrinsicToGeographic(xIntrinsic, yIntrinsic)
```

Description

`[lat, lon] = R.intrinsicToGeographic(xIntrinsic, yIntrinsic)` returns the geographic coordinates `(lat, lon)` of a set of points, given their intrinsic coordinates `(xIntrinsic, yIntrinsic)` and based on the relationship defined by referencing object `R`. `xIntrinsic` and `yIntrinsic` have the same size. `lat` and `lon` have the same size as `xIntrinsic` and `yIntrinsic`.

The input can include points that fall outside the limits of the raster (or image). Latitudes and longitudes for such points are linearly extrapolated outside the geographic quadrangle bounding the raster. However, for any point that extrapolates to a latitude beyond the poles (latitude < −90 degrees or latitude > 90 degrees), the values of `lat` and `lon` are set to NaN.

spatialref.GeoRasterReference.intrinsicXToLongitude

Purpose

Convert from intrinsic *x* to longitude

Syntax

```
lon = R.intrinsicXToLongitude(xIntrinsic)
```

Description

`lon = R.intrinsicXToLongitude(xIntrinsic)` returns the longitude of the meridian corresponding to the line `x = xIntrinsic`, based on the relationship defined by referencing object `R`. The input can include values that fall completely outside the intrinsic *x*-limits of the raster (or image). In this case, longitude is extrapolated outside the longitude limits. NaN-valued elements of `xIntrinsic` map to NaNs in `lon`.

Purpose

Convert from intrinsic *y* to latitude

Syntax

```
lat = R.intrinsicYToLatitude(yIntrinsic)
```

Description

`lat = R.intrinsicYToLatitude(yIntrinsic)` returns the latitude of the small circle corresponding to the line `y = yIntrinsic`, based on the relationship defined by the referencing object `R`. The input can include values that fall completely outside the intrinsic *y*-limits of the raster (or image). In this case latitude is extrapolated outside the latitude limits, but for input values that extrapolate to latitudes beyond the poles (latitude < –90 degrees or latitude > 90 degrees), the value of `lat` is set to NaN. NaN-valued elements of `yIntrinsic` map to NaNs in `lat`.

spatialref.GeoRasterReference.latitudeToIntrinsicY

Purpose

Convert from latitude to intrinsic *y*

Syntax

```
yIntrinsic = R.latitudeToIntrinsicY(lat)
```

Description

`yIntrinsic = R.latitudeToIntrinsicY(lat)` returns the intrinsic `Y` value of the line corresponding to the small circle at latitude `lat`, based on the relationship defined by referencing object `R`. The input can include values that fall completely outside the latitude limits of the raster (or image). In this case, `yIntrinsic` is either extrapolated outside the intrinsic `Y` limits, for elements of `lat` that fall within the interval `[-90 90]` degrees, or set to NaN, for elements of `lat` that do not correspond to valid latitudes. NaN-valued elements of `lat` map to NaNs in `yIntrinsic`.

Purpose

Convert from longitude to intrinsic *x*

Syntax

```
xIntrinsic = R.longitudeToIntrinsicX(lon)
```

Description

`xIntrinsic = R.longitudeToIntrinsicX(lon)` returns the intrinsic *x* value of the line corresponding to the meridian at longitude `lon`, based on the relationship defined by referencing object `R`. The input can include values that fall completely outside the longitude limits of the raster (or image). In this case, `xIntrinsic` is extrapolated outside the intrinsic *x* limits. NaN-valued elements of `lon` map to NaNs in `xIntrinsic`.

spatialref.GeoRasterReference.sizesMatch

Purpose

True if object and raster or image are size compatible

Syntax

```
TH = R.sizesMatch(A)
```

Description

`TH = R.sizesMatch(A)` returns `true` if the size of the raster or image `A` is consistent with the `RasterSize` property of referencing object `R`. That is:

```
R.RasterSize == [size(A,1) size(A,2)]
```

Purpose

World file parameters for transformation

Syntax

```
W = R.worldFileMatrix
```

Description

`W = R.worldFileMatrix` returns a 2-by-3 world file matrix. Each of the six elements in `W` matches one of the lines in a world file corresponding to the transformation defined by referencing object `R`.

Given `W` with the form:

```
W = [A B C;
     D E F]
```

a point `(xi, yi)` in intrinsic coordinates maps to a point `(lat, lon)` in geographic coordinates like this:

```
lon = A * (xi   1) + B * (yi   1) + C
lat = D * (xi   1) + E * (yi   1) + F
```

More compactly:

```
[lon lat]' = W * [xi   1  yi   1  1]'
```

The −1s allow the world file matrix to work with the Mapping Toolbox convention for intrinsic coordinates, which is consistent with the 1-based indexing used throughout MATLAB.

`W` is stored in a world file with one term per line in column-major order: A, D, B, E, C, F. That is, a world file contains the elements of `W` in this order:

```
W(1,1)
W(2,1)
W(1,2)
W(2,2)
W(1,3)
W(2,3)
```

More compactly:

```
[lon lat]' = W * [(xi-1)(yi-1) 1]'
```

The previous expressions hold for a general affine transformation. But in the matrix returned by this method `B`, `D`, `W(2,1)` and `W(1,2)` are identically 0 because longitude depends only on intrinsic x and latitude depends only on intrinsic y.

See Also

`worldfileread` | `worldfilewrite`

Purpose

Geographic shape vector

Syntax

```
s = geoshape()
s = geoshape(lat,lon)
s = geoshape(lat,lon,Name,Value)
s = geoshape(structArray)
s = geoshape(lat,lon,structArray)
```

Description

A geoshape vector is an object that represents geographic vector features with either point, line, or polygon topology. The features consist of latitude and longitude coordinates and associated attributes. If these attributes vary spatially they are termed Vertex properties. These elements of the geoshape vector are coupled such that the length of the latitude and longitude coordinate property values are always equal in length to any additional dynamic Vertex properties. Attributes which only pertain to the overall feature (point, line, polygon) are termed Feature properties. Feature properties are not linked to the auto-sizing mechanism of the Vertex properties. Both of the property types can be dynamically added to a geoshape vector using the standard dot notation.

A geoshape vector is always a column vector.

Construction

`s = geoshape()` constructs an empty geoshape vector, `s`, with the following default property settings.

```
s =

 0x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'line'
     Metadata: [1x1 struct]
 Vertex properties:
     Latitude: []
    Longitude: []
```

For an additional example see: “Constructor: geoshape()” on page 3-414

`s = geoshape(lat,lon)` constructs a geoshape vector and sets the `Latitude` and `Longitude` property values equal to vectors `lat` and `lon`. `lat` and `lon` may be either numeric vectors of class single or double, or cell arrays containing numeric vectors of class single or double. For an example, see "Constructor: geoshape(lat,lon)" on page 3-415.

`s = geoshape(lat,lon,Name,Value)` constructs a geoshape vector from the input `lat` and `lon` vectors, and then adds dynamic properties to the geoshape vector using the `Name`, `Value` argument pairs.

- If `Value` is in a cell array containing numeric, logical or cell array of strings, then this property is designated as a Vertex property. Otherwise, this property is designated as a Feature property.
- If the specified `Name` is `Metadata` and the corresponding `Value` is a scalar structure, then `Value` is copied to the `Metadata` property. Otherwise, an error is issued.

For an example, see: "Constructor: geoshape(lat,lon,Name,Value)" on page 3-415.

`s = geoshape(structArray)` constructs a `geoshape` vector from the fields of the structure array, `structArray`.

- If `structArray` contains the field `Lat`, and does not contain a field `Latitude`, then the `Latitude` property values are set equal to the `Lat` field values. If `structArray` contains the field, `Lon`, and does not contain a field `Longitude`, then the `Longitude` property values are set equal to the `Lon` field values.
- If `structArray` contains both `Lat` and `Latitude` fields, then the `Latitude` property values are set equal to the `Latitude` field values and a `Lat` dynamic property is created whose values are set equal to the `Lat` field values. Similar behavior occurs for `Longitude` and `Lon` field combinations if present in `structArray`.
- If `structArray` is a scalar structure which contains the field `Metadata` and the field value is a scalar structure, then the `Metadata` field is copied to the `Metadata` property. If `structArray` is a scalar

structure and the `Metadata` field is present and is not a scalar structure, then an error is issued. If `structArray` is not scalar then the `Metadata` field is ignored.

- Other fields of `structArray` are assigned to `s` and become dynamic properties. Field values in `structArray` that are not numeric, strings, logical, or cell arrays of numeric, logical, or string values are ignored.

For an example, see "Constructor: geoshape(structArray)" on page 3-416.

`s = geoshape(lat,lon,structArray)` constructs a new `geoshape` vector and sets the `Latitude` and `Longitude` properties equal to the numeric vectors, `lat` and `lon`, and sets the field values of struct `structArray` as dynamic properties.

- If `structArray` contains the fields `Lat`, `Latitude`, `Lon` or `Longitude`, then those field values are ignored since the `Latitude` and `Longitude` property values are set by the `lat` and `lon` input vectors.
- If `structArray` is a scalar structure and contains the field `Metadata`, and the field value is a scalar structure, then it is copied to the `Metadata` property value. Otherwise, an error is issued if the `Metadata` field is not a structure, or ignored if `structArray` is not scalar.

For an example, see "Constructor: geoshape(lat,lon,structArray)" on page 3-417.

Input Arguments

lat

vector of latitude coordinates

Data Types
double | single | cell

lon

vector of longitude coordinates

Data Types
double | single | cell

structArray

An array of structures containing fields to be assigned as dynamic properties.

Name

Name of dynamic property

Data Types
char

Value

Property value associated with dynamic property `Name`. The class type of the values for the Feature dynamic properties may be either numeric, logical, char, or a cell array of strings. Values for the Vertex dynamic properties may be either numeric, logical, cell array of strings, or a cell array of numeric, logical, or cell array of strings.

Output Arguments

s

geoshape vector.

Properties

`geoshape` class is a general class that represents a variety of geographic features. The class permits features to have more than one vertex and can thus represent lines and polygons in addition to multipoints. The class has the following property types.

Types of Properties	Description
Collection Properties	Collection properties contain only one value per class instance. This is in contrast to the other two property types which can have attribute values associated with each feature or with each vertex in a set that defines a feature. Geometry and Metadata are the only two Collection properties.
Vertex Properties	Vertex properties provide a scalar number or a string for each vertex in a geoshape object. Vertex properties are suitable for attributes that vary spatially from point to point (vertex to vertex) along a line. Examples of such spatially varying attributes could be elevation, speed, temperature, or time. Latitude and Longitude are vertex properties since they contain a scalar number for each vertex in a geoshape vector. Attribute values can be dynamically associated with each vertex by using dot notation. This is similar to adding dynamic fields to a structure. The dynamically added vertex property values of an individual feature match its Latitude and Longitude values in length.
Feature Properties	Feature properties provide one value (a scalar number or a string) for each feature in a geoshape vector. They are suitable for properties, such as name, owner, serial number, age, etc., that describe a given feature (an element of a geoshape vector) as a whole. Like Vertex properties, Feature properties can be added dynamically.

Geometry

The `Geometry` property is a string that denotes the shape type for all the features in the geoshape vector. As a Collection Property there is only one value per object instance. Its purpose is purely

informational; the three allowable string values for `Geometry` do not change class behavior. Additionally, the class does not provide validation for line or polygon topologies.

Default value for `Geometry` is `` `line' ``.

`Geometry`	`'point', 'line', 'polygon'`

Metadata

Metadata is a scalar structure containing information for all the features. You can add any data type to the structure. As a Collection Property type, only one instance per object is allowed.

`Metadata`	`Scalar struct`

Latitude

Vector of latitude coordinates. The values can be either a row or column vector, but are stored as a row vector.

Attributes:

`Latitude`	`single | double vector`

Longitude

Vector of longitude coordinates. The values can be either a row or column vector, but are stored as a row vector.

Attributes:

`Longitude`	`single | double vector`

Methods

append	Append features to geoshape vector
cat	Concatenate geoshape vectors

disp	Display geoshape vector
fieldnames	Dynamic properties of geoshape vector
isempty	True if geoshape vector is empty
isfield	True if dynamic property exists
isprop	True if property exists
length	Number of elements in geoshape vector
properties	Properties of a geoshape vector
rmfield	Remove dynamic property from geoshape vector
rmprop	Remove properties from geoshape vector
size	Size of `geoshape` vector
struct	Convert geoshape vector to scalar structure
vertcat	Vertical concatenation for geoshape vectors

Copy Semantics

Value. To learn how value classes affect copy operations, see Copying Objects in the MATLAB Programming Fundamentals documentation.

Class Behaviors

- The following examples show how to build geoshape vectors with single or multiple features.

  "Single Line Feature" on page 3-417

  "Multiple Point Features" on page 3-419

- You can attach dynamic feature and vertex properties to a geoshape vector by either adding them at construction or by using the dot (.) notation after construction. This is similar to adding new fields

to a structure. The following examples highlight the two ways by which a geoshape vector with the same features can be created. In each example the data is read from the same file into a structure array. The first example dynamically adds the features to a geoshape object created with the default constructor. The second example uses the structure array as an argument to constructor which builds the geoshape vector.

"Dynamically Adding Multiple Line Features" on page 3-420

"Multiple Line Features Using a Constructor" on page 3-422

- The geoshape vector can be indexed like any MATLAB vector. You can access any element of the vector to obtain a specific feature. The following examples demonstrate this behavior.

  "Indexing: Appending to a Point geoshape vector" on page 3-424

  "Indexing: Sorting and Modifying Dynamic Features" on page 3-427

  "Indexing: an Extended Example" on page 3-430

- The following example demonstrates the behavior of differing vector representations of the `Latitude` and `Longitude` properties.

  "Row and Column Vectors for `Latitude` and `Longitude`" on page 3-432

- If either `Latitude` or `Longitude` is set to [ ], then both coordinate properties are set to [ ] and all dynamic Vertex or Feature properties are removed.

- If a Vertex or Feature property is set to [ ], then it is removed from the object.

Examples

Constructor: geoshape()

Construct a default geoshape vector, dynamically set the Latitude and Longitude property values, and dynamically add Vertex property `Z`.

```
s = geoshape();
s(1).Latitude = 0:45:90;
```

```
s(1).Longitude = [10 10 10];
s(1).Z = [10 20 30]

s =

 1x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'line'
     Metadata: [1x1 struct]
 Vertex properties:
     Latitude: [0 45 90]
    Longitude: [10 10 10]
            Z: [10 20 30]
```

Constructor: geoshape(lat,lon)

Construct a geoshape vector from latitude and longitude values.

```
s = geoshape([42 43 45], [10 11 15])

s =

 1x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'line'
     Metadata: [1x1 struct]
 Vertex properties:
     Latitude: [42 43 45]
    Longitude: [10 11 15]
```

Constructor: geoshape(lat,lon,Name,Value)

Construct a geoshape vector with one feature from a single position coordinate, and a `Name`,`Value` pair defining a 'Temperature' Feature property.

```
point = geoshape(42, -72, 'Temperature', 89);
point.Geometry = 'point'
```

```
point =

 1x1 geoshape vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Vertex properties:
       Latitude: 42
      Longitude: -72
 Feature properties:
    Temperature: 89
```

When `Value` is a cell array containing numeric, logical, or cell array of strings, it is construed as a Vertex property. Otherwise the `Name-Value` pair is designated as being a Feature property.

Constructor: geoshape(structArray)

Construct a geoshape vector from a structure array.

```
structArray = shaperead('worldrivers', 'UseGeoCoords', true);
shape = geoshape(structArray)

s =

 128x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'line'
     Metadata: [1x1 struct]
 Vertex properties:
  (128 features concatenated with 127 delimiters)
     Latitude: [1x5542 double]
    Longitude: [1x5542 double]
 Feature properties:
         Name: {1x128 cell}
```

Constructor: geoshape(lat,lon,structArray)

Construct a geoshape vector using cell arrays to define multifeatures and a structure array to define a set of Feature properties.

```
[structArray2, structNames] = shaperead('worldrivers', 'UseGeoCoords',
s = geoshape({structArray2.Lat}, {structArray2.Lon}, structNames)
```

```
s =

 128x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'line'
     Metadata: [1x1 struct]
 Vertex properties:
  (128 features concatenated with 127 delimiters)
     Latitude: [1x5542 double]
    Longitude: [1x5542 double]
 Feature properties:
         Name: {1x128 cell}
```

Single Line Feature

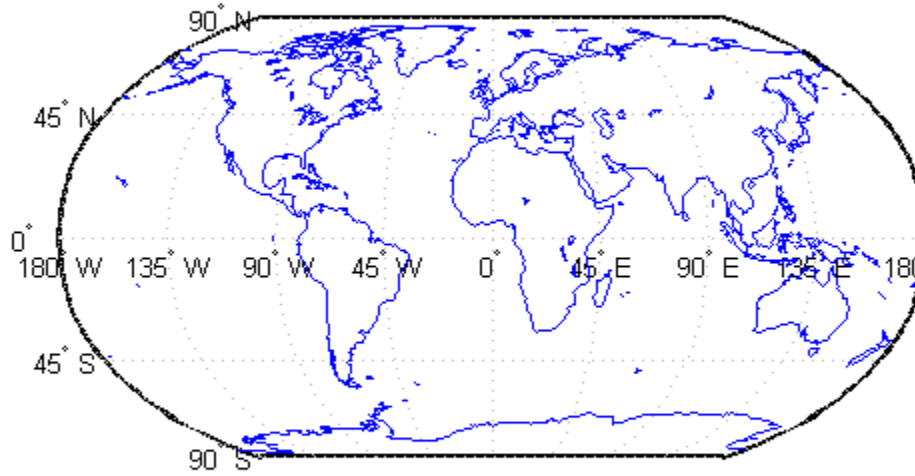
Construct a geoshape vector with one feature from latitude and longitude coordinates. Dynamically add a Feature property and display it.

```
coast = load('coast')
s = geoshape(coast.lat, coast.long);

s.Name = 'coastline'

figure
worldmap world
geoshow(s.Latitude, s.Longitude)
```

```
coast =
```

```
     lat: [9865x1 double]
    long: [9865x1 double]
s =

 1x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'line'
     Metadata: [1x1 struct]
 Vertex properties:
     Latitude: [1x9865 double]
    Longitude: [1x9865 double]
 Feature properties:
         Name: 'coastline'
```

Note that the Feature property `Name` applies to the entire set of vertices defined by the `Geometry` property as representing a `` `line' ``.



Multiple Point Features

Construct a geoshape vector from latitude, longitude, and temperature values and define them as point features.

```
lat = {42, 42.3};
lon = {-72, -72.85};
temperature = {89, 87.5};
s = geoshape(lat, lon, 'Temperature', temperature);
s.Geometry = 'point'
```

Note that the number of `temperature` entries match the number of `lat` and `lon` entries which causes this attribute to be classified as a `Vertex property`.

```
s =

 2x1 geoshape vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Vertex properties:
  (2 features concatenated with 1 delimiter)
       Latitude: [42 NaN 42.3000]
      Longitude: [-72 NaN -72.8500]
    Temperature: [89 NaN 87.5000]
```

Dynamically Adding Multiple Line Features

Construct a geoshape vector containing 128 elements by setting `Latitude` and `Longitude` property values and then dynamically adding a new Feature property.

The entire structure array, `structArray`, contains 128 elements; each element defines a river as a line using multiple location vertices.

```
structArray = shaperead('worldrivers', 'UseGeoCoords', true)


structArray =

128x1 struct array with fields:
    Geometry
    BoundingBox
    Lon
    Lat
    Name
```

Display one element in the 128 element structure array.

```
structArray(1)       %

ans =

       Geometry: 'Line'
    BoundingBox: [2x2 double]
            Lon: [126.7796 126.5321 126.3121 126.2383 126.0362 NaN]
            Lat: [73.4571 73.0669 72.8343 72.6010 72.2894 NaN]
           Name: 'Lena
```

Note that the `Lat` and `Lon` vectors are terminated with a `NaN` delimiter.

Dynamically add Vertex properties from each entry in the structure array. Then add a Feature property: the name of each of the 128 rivers in `shape`.

```
shape = geoshape();

for k=1:length(shape)
   shape(k).Latitude  = structArray(k).Lat;
   shape(k).Longitude = structArray(k).Lon;
end

shape.Name = {structArray.Name}

shape =

 128x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'line'
     Metadata: [1x1 struct]
 Vertex properties:
  (128 features concatenated with 127 delimiters)
     Latitude: [1x5542 double]
    Longitude: [1x5542 double]
```

```
 Feature properties:
        Name: {1x128 cell}
```

Note that the features are concatenated with a `NaN` delimiter.

Since the default value of the `Geometry` Collection property is `'line'` there is no need to set it explicitly in this example.

Multiple Line Features Using a Constructor

Construct a geoshape vector from a structure array.

Read in structure array containing 128 elements which define world rivers. Display one element of the array.

```
structArray = shaperead('worldrivers', 'UseGeoCoords', true)
structArray(1)
```

```
ans =

       Geometry: 'Line'
    BoundingBox: [2x2 double]
            Lon: [126.7796 126.5321 126.3121 126.2383 126.0362 NaN]
            Lat: [73.4571 73.0669 72.8343 72.6010 72.2894 NaN]
           Name: 'Lena'
```

Note that the `Lat` and `Lon` vectors are terminated with `NaN` delimiters which used to separate the Vertex feature data in the geoshape class.

The structure array contains all the data needed to construct the 128 element geoshape vector.

```
shape = geoshape(structArray)
```

```
shape =

 128x1 geoshape vector with properties:

 Collection properties:
```

```
    Geometry: 'line'
    Metadata: [1x1 struct]
 Vertex properties:
  (128 features concatenated with 127 delimiters)
    Latitude: [1x5542 double]
   Longitude: [1x5542 double]
 Feature properties:
        Name: {1x128 cell}
```

Display only the first 5 feature elements of the geoshape vector.

```
shape(1:5)
```

```
ans =

 5x1 geoshape vector with properties:

 Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
 Vertex properties:
  (5 features concatenated with 4 delimiters)
    Latitude: [1x52 double]
   Longitude: [1x52 double]
 Feature properties:
        Name: {'Lena' 'Lena' 'Mackenzie' 'Mackenzie' 'Kolyma'}
```

Note that indexing of the first five elements of the geoshape vector displays the corresponding number of Feature properties in `Name`.

Add a filename field to the `Metadata` structure which is a Collection property and thus applies to all features in the object.

```
shape.Metadata.Filename = 'worldcities.shp';
shape.Metadata
```

```
ans =
```

```
    Filename: 'worldcities.shp'
```

Indexing: Appending to a Point geoshape vector

Append a single point and a shape to a geoshape vector.

Create a geoshape vector containing a single feature of the locations of world cities.

```
S = shaperead('worldcities.shp', 'UseGeoCoords', true);
cities = geoshape([S.Lat], [S.Lon], 'Name', {{S.Name}});
cities.Geometry = 'point';
```

Append Paderborn Germany to the geoshape vector.

```
lat = 51.715254;
lon = 8.75213;
cities(1).Latitude(end+1) = lat;
cities(1).Longitude(end) = lon;
cities(1).Name{end} = 'Paderborn'
```

```
cities =

 1x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Vertex properties:
     Latitude: [1x319 double]
    Longitude: [1x319 double]
         Name: {1x319 cell}
```

The length of each vertex property grows by 1 when Latitude(end+1) is set. The remaining properties are indexed with `end`.

You can display the last point by constructing a geopoint vector.

```
paderborn = geopoint(cities.Latitude(end), cities.Longitude(end), ...
```

```
   'Name', cities.Name{end})

paderborn =

 1x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: 51.7153
    Longitude: 8.7521
         Name: 'Paderborn'
```

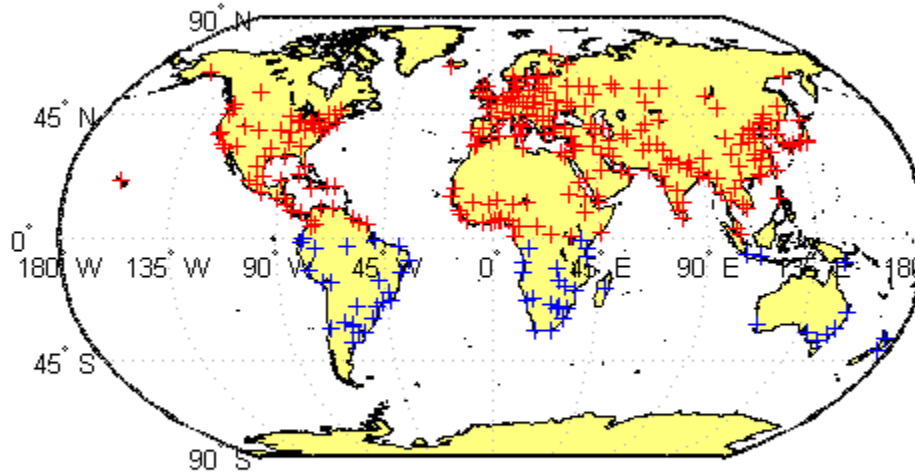
Create a new geoshape vector with two new features containing the cities in the northern and southern hemispheres. Add a Location dynamic feature property to distinguish the different classifications.

```
northern = cities(1).Latitude >= 0;
southern = cities(1).Latitude < 0;
index = {northern; southern};
location = {'Northern Hemisphere', 'Southern Hemisphere'};
hemispheres = geoshape();
for k = 1:length(index)
   hemispheres = append(hemispheres, ...
      cities.Latitude(index{k}), cities.Longitude(index{k}), ...
      'Name', {cities.Name(index{k})}, 'Location', location{k});
end
hemispheres.Geometry = 'point'

hemispheres =

 2x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
```

```
 Vertex properties:
  (2 features concatenated with 1 delimiter)
     Latitude: [1x320 double]
    Longitude: [1x320 double]
         Name: {1x320 cell}
 Feature properties:
     Location: {'Northern Hemisphere' 'Southern Hemisphere'}
```

Plot the northern cities in red and the southern cities in blue.

```
hemispheres.Color = {'red', 'blue'};
figure;worldmap('world')
geoshow('landareas.shp')
for k=1:2
   geoshow(hemispheres(k).Latitude, hemispheres(k).Longitude, ...
      'DisplayType', hemispheres.Geometry, ...
      'MarkerEdgeColor', hemispheres(k).Color)
end
```



Indexing: Sorting and Modifying Dynamic Features

This example illustrates working with the dynamic features of a geoshape vector.

Construct a geoshape vector with the dynamic properties sorted.

```
shape = geoshape(shaperead('tsunamis', 'UseGeoCoords', true));
shape.Geometry = 'point';
shape = shape(:, sort(fieldnames(shape)))
```

```
shape =

 162x1 geoshape vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Vertex properties:
  (162 features concatenated with 161 delimiters)
       Latitude: [1x323 double]
      Longitude: [1x323 double]
 Feature properties:
          Cause: {1x162 cell}
     Cause_Code: [1x162 double]
        Country: {1x162 cell}
            Day: [1x162 double]
    Desc_Deaths: [1x162 double]
         Eq_Mag: [1x162 double]
           Hour: [1x162 double]
       Iida_Mag: [1x162 double]
      Intensity: [1x162 double]
       Location: {1x162 cell}
     Max_Height: [1x162 double]
         Minute: [1x162 double]
          Month: [1x162 double]
     Num_Deaths: [1x162 double]
         Second: [1x162 double]
       Val_Code: [1x162 double]
       Validity: {1x162 cell}
           Year: [1x162 double
```

Modify the geoshape vector to contain only the dynamic properties, `Year`, `Month`, `Day`, `Hour`, `Minute`.

```
shape = shape(:, {'Year', 'Month', 'Day', 'Hour', 'Minute'})
```

```
shape =

 162x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Vertex properties:
  (162 features concatenated with 161 delimiters)
     Latitude: [1x323 double]
    Longitude: [1x323 double]
 Feature properties:
         Year: [1x162 double]
        Month: [1x162 double]
          Day: [1x162 double]
         Hour: [1x162 double]
       Minute: [1x162 double]
```

Display the first 5 elements.

```
shape(1:5)
```

```
ans =

 5x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Vertex properties:
  (5 features concatenated with 4 delimiters)
     Latitude: [-3.8000 NaN 19.5000 NaN -9.0200 NaN 42.1500 NaN 19.100
    Longitude: [128.3000 NaN -156 NaN 157.9500 NaN 143.8500 NaN -155]
 Feature properties:
         Year: [1950 1951 1951 1952 1952]
        Month: [10 8 12 3 3]
          Day: [8 21 22 4 17]
```

```
        Hour: [3 10 NaN 1 3]
      Minute: [23 57 NaN 22 58]
```

Indexing: an Extended Example

This example illustrates how to construct a two-element geoshape vector containing GPS track log data.

Read multiple GPS track log data from a file. `trk1` and `trk2` are geopoint objects.

```
trk1 = gpxread('sample_tracks')
trk2 = gpxread('sample_tracks', 'Index', 2);
```

```
trk1 =

 1851x1 geopoint vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Feature properties:
     Latitude: [1x1851 double]
    Longitude: [1x1851 double]
    Elevation: [1x1851 double]
         Time: {1x1851 cell}
```

To construct a geoshape vector with multiple features, place the coordinates into cell arrays.

```
lat = {trk1.Latitude, trk2.Latitude};
lon = {trk1.Longitude, trk2.Longitude};
```

To create dynamic vertex properties (a property with a value at each coordinate), place the elevation and time values into cell arrays.

```
elevation = {trk1.Elevation, trk2.Elevation};
time = {trk1.Time, trk2.Time};
```

Construct a geoshape vector containing two track log features that include `Elevation` and `Time` as dynamic Vertex properties.

```
tracks = geoshape(lat, lon, 'Elevation', elevation, 'Time', time)
```

```
tracks =

 2x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'line'
     Metadata: [1x1 struct]
 Vertex properties:
  (2 features concatenated with 1 delimiter)
     Latitude: [1x2592 double]
    Longitude: [1x2592 double]
    Elevation: [1x2592 double]
         Time: {1x2592 cell}
```

Each `Latitude` and `Longitude` coordinate pair has associated `Elevation` and `Time` values which are Vertex properties.

To construct a geoshape vector containing a dynamic Feature property, use an array that is the same length as the coordinate cell array. For example, construct a geoshape vector as before and add a `MaximumElevation` dynamic Feature property.

```
tracks_max = geoshape(lat, lon, 'Elevation', elevation, 'Time', time,
    'MaximumElevation', [max(trk1.Elevation) max(trk2.Elevation)])
```

```
tracks_max =

 2x1 geoshape vector with properties:

 Collection properties:
            Geometry: 'line'
            Metadata: [1x1 struct]
 Vertex properties:
```

```
  (2 features concatenated with 1 delimiter)
            Latitude: [1x2592 double]
           Longitude: [1x2592 double]
           Elevation: [1x2592 double]
                Time: {1x2592 cell}
 Feature properties:
    MaximumElevation: [92.4240 76.1000]
```

The Feature property value has only two numeric values, one for each feature.

Row and Column Vectors for `Latitude` and `Longitude`

If you typically store latitude and longitude coordinate values in a N-by-2 or 2-by-M array, you can assign a geoshape vector to these numeric values.

If the values are stored in a N-by-2 array, then the `Latitude` property values are assigned to the first column and the `Longitude` property values are assigned to the second column.

```
coast = load('coast');
pts = [coast.lat coast.long];
shape = geoshape();
shape(1) = pts
```

```
shape =

 1x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'line'
     Metadata: [1x1 struct]
 Vertex properties:
     Latitude: [1x9865 double]
    Longitude: [1x9865 double]
```

If the values are stored in a 2-by-M array, then the `Latitude` property values are assigned to the first row and the `Longitude` property values are assigned to the second row.

```
pts = [coast.lat'; coast.long'];
shape = geoshape();
shape(1) = pts
```

```
shape =

 1x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'line'
     Metadata: [1x1 struct]
 Vertex properties:
     Latitude: [1x9865 double]
    Longitude: [1x9865 double]
```

See Also

`gpxread` | `shaperead` | `mappoint` | `geopoint` | `mapshape`

geoshape.append

Purpose

Append features to geoshape vector

Syntax

```
s = append(s,lat,lon)
s = append(s,lat,lon,Name,Value)
```

Description

`s = append(s,lat,lon)` appends the vector, `lat`, to the `Latitude` property values of the geoshape vector, `s`, and the vector, `lon`, to the `Longitude` property values of `s`. `lat` and `lon` are either vectors of class single or double or cell arrays containing numeric arrays of class single or double.

`s = append(s,lat,lon,Name,Value)` appends the `lat` and `lon` vectors to the `Latitude` and `Longitude` property values of the geoshape vector, `s`, and appends the values specified in the `Name,Value` pairs to the corresponding dynamic properties specified by the names in the `Name,Value` pairs if the properties are present in the object. Otherwise, the method adds dynamic properties to the object using the `Name` for the dynamic property names and assigns the corresponding `Value`.

Input Arguments

s

geoshape vector.

lat

Numeric vector of `Latitude` values.

lon

Numeric vector of `Longitude` values.

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

Name,Value

Parameter Name-Value pairs of the dynamic properties that are to be added to the geoshape vector, `s`.

Output Arguments

s

Modified geoshape vector with additional entries in `Latitude` and `Longitude` fields along with any new fields for dynamic properties that you added.

Examples

Append Values to Fields in a geoshape vector

Append values to existing fields of a geoshape vector

```
lat1 = [42, 42.2, 43];
lon1 = [-110, -110.3, -110.5];
temp1 = [65, 65.1, 68];
s = geoshape(lat1,lon1,'Temperature',{temp1})
```

```
s =

 1x1 geoshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
 Vertex properties:
       Latitude: [42 42.2000 43]
      Longitude: [-110 -110.3000 -110.5000]
    Temperature: [65 65.1000 68]
```

Now append data representing another feature.

```
lat2 = [43, 43.1, 44, 44.1];
lon2 = [-110.1, -111, -111.12, -110.8];
temp2 = [66, 66.1, 68.3, 69];
s = append(s,lat2,lon2,'Temperature', {temp2})
```

```
s =
```

```
2x1 geoshape vector with properties:

Collection properties:
      Geometry: 'line'
      Metadata: [1x1 struct]
Vertex properties:
 (2 features concatenated with 1 delimiter)
      Latitude: [42 42.2000 43 NaN 43 43.1000 44 44.1000]
     Longitude: [-110 -110.3000 -110.5000 NaN -110.1000 -111 -111.1200 -
   Temperature: [65 65.1000 68 NaN 66 66.1000 68.3000 69]
```

Note that the geoshape vector grew from 1x1 to 2x1 in length.

See Also

`geoshape` | `geoshape.vertcat` |

Purpose

Concatenate geoshape vectors

Syntax

```
s= cat(dim,s1, s2, ...)
```

Description

`s= cat(dim,s1, s2, ...)` concatenates the geoshape vectors `s1`,`s2` and so on along dimensions `dim`. `dim` must be `1`.

Input Arguments

`s1, s2, ...`

geoshape vectors to be concatenated.

Output Arguments

`s`

Concatenated geoshape vector.

Examples

Concatenate two geoshape vectors

Create two geoshape vectors and concatenate them into a single vector.

```
s1 = geoshape(42,-110, 'Temperature', 65);
s2 = geoshape(42.2, -110.5, 'Temperature', 65.6);
s1s2 = cat(1,s1,s2)
```

```
s1s2 =

 2x1 geoshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
 Vertex properties:
  (2 features concatenated with 1 delimiter)
       Latitude: [42 NaN 42.2000]
      Longitude: [-110 NaN -110.5000]
 Feature properties:
    Temperature: [65 65.6000]
```

See Also

`geoshape.vertcat` |

geoshape.disp

Purpose

Display geoshape vector

Syntax

```
disp(s)
```

Description

`disp(s)` prints the size of the geoshape vector, `s`, and its properties and dynamic properties, if they exist. If the command window is large enough, the values of the properties are also shown, otherwise only their size is shown. You can control the display of the numerical values by using the format command.

Input Arguments

`s`

geoshape vector.

Examples

Display a geoshape vector

Display a geoshape vector.

```
s = geoshape(shaperead('worldcities', 'UseGeo', true));
disp(s)
disp(s(1:2))
```

```
 318x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'point'
     Metadata: [1x1 struct]
 Vertex properties:
  (318 features concatenated with 317 delimiters)
     Latitude: [1x635 double]
    Longitude: [1x635 double]
 Feature properties:
         Name: {1x318 cell}

 2x1 geoshape vector with properties:

 Collection properties:
     Geometry: 'point'
```

```
    Metadata: [1x1 struct]
Vertex properties:
 (2 features concatenated with 1 delimiter)
    Latitude: [5.2985 NaN 24.6525]
   Longitude: [-3.9509 NaN 54.7589]
Feature properties:
        Name: {'Abidjan' 'Abu Dhabi'}
```

See Also

formatgeoshape |

geoshape.fieldnames

Purpose

Dynamic properties of geoshape vector

Syntax

```
names = fieldnames(s)
```

Description

`names = fieldnames(s)` returns the names of the dynamic properties of the geoshape vector, `s`.

Input Arguments

`s`

geoshape vector for which the properties are to be queried.

Output Arguments

`names`

Names of the dynamic properties in the geoshape vector `s`

Examples

Find dynamic properties

Return the dynamic properties of a geoshape vector

```
s = geoshape(shaperead('worldcities', 'UseGeo', true));
fieldnames(s)
```

```
ans =

    'Name'
```

See Also

`geoshape.properties` |

Purpose

True if geoshape vector is empty

Syntax

```
tf = isempty(s)
```

Description

`tf = isempty(s)` returns true if the geoshape vector, `s`, is empty and false otherwise.

Input Arguments

`s`

geoshape vector.

Output Arguments

`tf`

`Boolean`. 1 if `s` is empty or 0 if not.

Examples

Check if a geoshape vector is empty

Check if the geoshape vector is empty.

```
s = geoshape();
isempty(s)
```

```
ans =

     1
```

See Also

`geoshape.end` |

geoshape.isfield

Purpose

True if dynamic property exists

Syntax

```
tf = isfield(s,name)
tf = isfield(s,names)
```

Description

`tf = isfield(s,name)` returns true if the value specified by the string `name` is a dynamic property of the geoshape vector, `s`.

`tf = isfield(s,names)` return true for each element of the cell array, `names`, that is a dynamic property of `s`. `tf` is a logical array of the same size as `names`.

Input Arguments

s

geoshape vector.

name

Name of the dynamic property.

names

Cell array of names of dynamic properties.

Output Arguments

tf

`Boolean`. 1 if `s` contains the specified fields or 0 otherwise.

Examples

Check for fieldname

Check if a field is present in a geoshape vector.

```
s = geoshape(-33.961, 18.484, 'Name', 'Cape Town')
isfield(s, 'Latitude')
isfield(s, 'Name')
```

```
s =

 1x1 geoshape vector with properties:
```

```
 Collection properties:
     Geometry: 'line'
     Metadata: [1x1 struct]
 Vertex properties:
     Latitude: -33.9610
    Longitude: 18.4840
 Feature properties:
         Name: 'Cape Town'


ans =

     0


ans =

     1
```

Note that `Latitude` returns 0 because it is not a dynamically added property.

See Also

`geoshape.isprop` | `geoshape.fieldnames` |

geoshape.isprop

Purpose

True if property exists

Syntax

```
tf = isprop(s,name)
tf = isprop(s,names)
```

Description

`tf = isprop(s,name)` returns true if the value specified by the string, `name` is a property of the geoshape vector, `s`.

`tf = isprop(s,names)` returns true for each element of the cell array of strings, `names`, that is a property of `s`. `tf` is a logical array the same size as `names`.

Input Arguments

s

geoshape vector.

name

String specifying the property of the geoshape vector, `s`.

names

Cell array of strings specifying the property of the geoshape vector, `s`.

Output Arguments

tf

Boolean. 1 if the property exists with `s` ,0 otherwise.

Examples

Check if property exists

This example shows how to check if a string is a property of a geoshape vector.

```
s = geoshape(-33.961, 18.484, 'Name', 'Cape Town');
isprop(s, 'Latitude')
isprop(s, 'Name')
```

```
ans =

     1
```

```
ans =

     1
```

See Also

geoshape.isfield | geoshape.properties |

geoshape.length

Purpose

Number of elements in geoshape vector

Syntax

```
N = length(s)
```

Description

`N = length(s)` returns the number of elements contained in the geoshape vector, `s`. The result is equivalent to `size(s,1)`.

Input Arguments

`s`

geoshape vector.

Output Arguments

`N`

Length of the geoshape vector, `s`.

Examples

Find the length of the geoshape vector.

```
coast = load('coast');
s = geoshape(coast.lat, coast.long);
length(s)
length(coast.lat)
```

```
ans =

     1


ans =

        9865
```

See Also

`geoshape.size` |

Purpose

Properties of a geoshape vector

Syntax

```
prop = properties(s)
properties(s)
```

Description

`prop = properties(s)` returns a cell of the property names of the geoshape vector, `s`.

`properties(s)` displays the names of the properties of `s`.

Input Arguments

`s`

geoshape vector.

Output Arguments

`prop`

Cell variable consisting of property names of the geoshape vector, `s`.

Examples

Properties of a geoshape vector

Query for properties of a geoshape vector.

```
s = geoshape(shaperead('tsunamis', 'UseGeo', true));
properties(s)
```

```
Properties for class geoshape:

    Geometry
    Metadata
    Latitude
    Longitude
    Year
    Month
    Day
    Hour
    Minute
    Second
```

```
    Val_Code
    Validity
    Cause_Code
    Cause
    Eq_Mag
    Country
    Location
    Max_Height
    Iida_Mag
    Intensity
    Num_Deaths
    Desc_Deaths
```

See Also `geoshape.fieldnames` |

Purpose

Remove dynamic property from geoshape vector

Syntax

```
s = rmfield(s, fieldname)
s = rmfield(s, fields)
```

Description

`s = rmfield(s, fieldname)` removes the field specified by the string, `fieldname` , from the geoshape vector, `s`.

`s = rmfield(s, fields)` removes all the fields specified by the cell array, `fields`.

Note `rmfield` cannot remove `Latitude`, `Longitude`, `Metadata` and `Geometry` fields. The specified string, '`fieldname`, is case sensitive.

Input Arguments

s

geoshape vector.

fieldname

Exact string representing the name of the property.

fields

Cell array of strings specifying the names of the properties.

Output Arguments

s

Updated geoshape vector with the field(s) removed.

Examples

Remove fields from a geoshape vector

Remove a field from a geoshape vector.

```
s = geoshape(shaperead('tsunamis', 'UseGeo', true));
tf = isfield(s,'Intensity')
s2 = rmfield(s,'Intensity');
tf = isfield(s2,'Intensity')
```

```
tf =

     1

tf =

     0
```

See Also

geoshape.fieldnames | geoshape.rmprop |

Purpose

Remove properties from geoshape vector

Syntax

```
sf = rmprop(s,propname)
sf = rmprop(s,propnames)
```

Description

`sf = rmprop(s,propname)` removes the property specified by the string, `propname` from the geoshape vector, `s`.

`sf = rmprop(s,propnames)` removes all the properties specified in the cell array, `propnames`, from the geoshape vector, `s`. If `propnames` contains a coordinate property an error is issued.

Note `rmprop` cannot remove `Latitude`, `Longitude`, `Metadata` and `Geometry` fields. The specified string, `propname`, is case sensitive.

Input Arguments

s

geoshape vector.

Output Arguments

sf

Modified geoshape vector with the specified property(s) removed.

Examples

Remove a property of a geoshape vector

Remove a property from a geoshape vector.

```
s = geoshape(shaperead('tsunamis', 'UseGeo', true));
tf = isfield(s,'Validity')
s2 = rmprop(s, 'Validity');
tf = isfield(s2,'Validity')
```

```
tf =

     1
```

```
tf =

     0
```

See Also geoshape.fieldnames |

Purpose

Size of geoshape vector

Syntax

```
val = size(s)
val = size(s,1)
val = size(s, n)
[m,k] = size(s)
```

Description

`val = size(s)` returns the vector `[length(val), 1]`.

`val = size(s,1)` returns the length of `s`.

`val = size(s, n)` returns `1` for `n >= 2`.

`[m,k] = size(s)` returns `length(s)` for `m` and `1` for `k`.

Input Arguments

s

geoshape vector.

n

Number of the dimension at which size of `s` is required.

Output Arguments

val

Vector of the form `[length(s), 1]`.

m

Length of `s`.

k

Length of second dimension of `s`. `k` is always `1`.

Examples

Size of a geoshape vector

Find the size of a geoshape vector.

```
structArray = shaperead('worldrivers', 'UseGeoCoords', true);
s= geoshape(structArray);
structSize = size(structArray)
```

```
sSize = size(s)

structSize =

   128     1


sSize =

   128     1
```

The second dimension is always 1.

See Also

`geoshape.length` | `size`

Purpose

Convert geoshape vector to scalar structure

Syntax

```
structArray = struct(s)
```

Description

`structArray = struct(s)` converts the geoshape vector, `s`, to a scalar structure array, `structArray`.

Input Arguments

s

geoshape vector.

Output Arguments

structArray

Scalar structure of the geoshape vector `s`.

Examples

Converting a geoshape vector into struct

This example shows how to convert a geoshape vector to `struct`.

```
structArray = shaperead('worldcities', 'UseGeo', true)
s= geoshape(structArray);
structArray2 = struct(s)
```

```
structArray =

318x1 struct array with fields:
    Geometry
    Lon
    Lat
    Name


structArray2 =

     Geometry: 'point'
     Metadata: [1x1 struct]
     Latitude: [1x635 double]
```

```
                Longitude: [1x635 double]
                     Name: {1x318 cell}
```

See Also geoshape.properties |

Purpose

Vertical concatenation for geoshape vectors

Syntax

```
s = vertcat(s1,s2, ...)
```

Description

`s = vertcat(s1,s2, ...)` vertically concatenates the geoshape vector, `s1, s2,` and so on. If the class type of any property is a cell array, then the resultant field in the output `s` will also be a cell array.

Input Arguments

`s1, s2, ...`

geoshape vectors to be concatenated.

Output Arguments

`s`

Concatenated geoshape vector.

Examples

Concatenate geoshape vectors

Concatenate two geoshape vectors.

```
s1 = geoshape(42, -110, 'Temperature', 65, 'Name', 'point1');
s2 = geoshape( 42.1, -110.4, 'Temperature', 65.5, 'Name', 'point2');
s = vertcat(s1, s2)
```

```
s =

 2x1 geoshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
 Vertex properties:
  (2 features concatenated with 1 delimiter)
       Latitude: [42 NaN 42.1000]
      Longitude: [-110 NaN -110.4000]
 Feature properties:
    Temperature: [65 65.5000]
           Name: {'point1' 'point2'}
```

See Also `geopoint.cat` |

Purpose

Display map latitude and longitude data

Syntax

```
geoshow(lat,lon)
geoshow(s)
geoshow(lat,lon,Z)
geoshow(Z,R)
geoshow(lat,lon,image)
geoshow(lat,lon,A,cmap)
geoshow(image,R)
geoshow(A,cmap,R)
geoshow(ax,...)
geoshow('Parent',ax,...)
geoshow(filename)
geoshow(...,Name,Value)
h = geoshow(...)
```

Description

`geoshow(lat,lon)` projects and displays the latitude and longitude vectors `lat` and `lon` using the projection stored in the axes. If there is no projection, `lat` and `lon` are projected using a default Plate Carrée projection. The default behavior for `geoshow` is to display `lat` and `lon` as lines.

`geoshow(s)` displays the vector geographic features stored in `s` as points, multipoints, lines, or polygons according to the `Geometry` field of `s`. If `s` includes `lat` and `lon` fields, then the coordinate values are projected to map coordinates. If `s` includes `X` and `Y` fields, then the coordinate values are plotted as preprojected map coordinates, and a warning is issued.

`geoshow(lat,lon,Z)` projects and displays a geolocated data grid.

`geoshow(Z,R)` projects and displays a regular data grid, `Z`.

`geoshow(lat,lon,image)` or `geoshow(lat,lon,A,cmap)` projects and displays a geolocated image as a texturemap on a zero-elevation surface. `lat`, `lon`, and the image array must match in size. Examples of geolocated images include a color composite from a satellite swath or an image originally referenced to a different coordinate system.

`geoshow(image,R)` or `geoshow(A,cmap,R)` projects and displays an image georeferenced to latitude-longitude through the referencing matrix `R`. The image is shown as a texturemap on a zero-elevation surface.

`geoshow(ax,...)` and `geoshow('Parent',ax,...)` set the parent axes to `ax`.

`geoshow(filename)` projects and displays data from the file specified according to the type of file format.

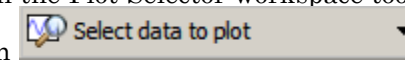
`geoshow(...,Name,Value)` specifies parameters and corresponding values that modify the type of display or set MATLAB graphics properties. Parameter names can be abbreviated, and case does not matter.

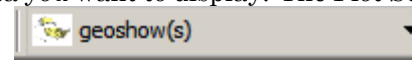
`h = geoshow(...)` returns a handle to a MATLAB graphics object.

Tips

- When calling `shaperead` to read files that contain coordinates in latitude and longitude, be sure to specify the `shaperead` argument pair `'UseGeoCoords',true`. If you do not include this argument, `shaperead` will create a mapstruct, with coordinate fields labelled `X` and `Y` instead of `Lon` and `Lat`. In such cases, `geoshow` assumes that the geostruct is in fact a mapstruct containing projected coordinates, warns, and calls `mapshow` to display the geostruct data without projecting it.
- If you do not want `geoshow` to draw on top of an existing map, create a new figure or subplot before calling it.
- When you display vector data in a map axes using `geoshow`, you should not subsequently change the map projection using `setm`. You can, however, change the projection with `setm` for raster data. For more information, see “Changing Map Projections when Using geoshow”.
- If you display a polygon, do not set `'EdgeColor'` to either `'flat'` or `'interp'`. This combination may result in a warning.
- When projecting data onto a map axes, `geoshow` uses the projection stored with the map axes. When displaying on a regular axes, it

constructs a default Plate Carrée projection with a scale factor of `180/pi`, enabling direct readout of coordinates in degrees.

- `geoshow` can generally be substituted for `displaym`. However, there are limitations where display of specific objects is concerned. See the remarks under `updategeostruct` for further information.
- You can access `geoshow` through the Plot Selector workspace tool, which is represented by this icon 

. In your workspace, select the data you want to display. The Plot Selector icon changes to look like this: 

. Scroll down to **geoshow(s): Plot a geostruct array**.

When you display raster data in a map using `geoshow`, columns near the eastern or western edge may fail to display. This is seldom noticeable, except when the raster is very coarse relative to the displayed area. To include additional columns in the display, it might help to:

- Resize the grid to a finer mesh
- Make sure the cell boundaries and map limits align
- Expand the map limits

Input Arguments

lat,lon

Latitude and longitude vectors. `lat` and `lon` must be of equal length. The vectors may contain embedded NaNs to delimit individual lines or polygon parts.

Z

M-by-N array. May contain NaN values.

s

Geographic data structure.

image

Grayscale, logical, or truecolor image.

A

Indexed image.

cmap

Colormap.

R

`spatialref.GeoRasterReference` object, referencing vector, or referencing matrix. If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to or from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Nearest-neighbor interpolation is used by default. NaN is returned for points outside the grid limits or for which `lat` or `lon` contain NaN. All angles are in units of degrees.

If `R` is a `spatialref.GeoRasterReference` object with raster interpretation `'postings'`, then the `'image'` and `'texturemap'` display types are not accepted.

ax

Axes object.

filename

Name of file.

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

SymbolSpec

A structure returned by `makesymbolspec` that specifies the symbolization rules to be used for displaying vector data. It is used only for vector data stored in geographic data structures. In cases where both `SymbolSpec` and one or more graphics properties are specified, the graphics properties override any settings in the symbolspec structure.

To change the default symbolization rule for a Name,Value pair in the symbolspec, prefix the word `'Default'` to the graphics property name.

DisplayType

Type of graphic display for the data. You can set any MATLAB Graphics line, patch, and surface properties. You can also set any Mapping Toolbox contour properties. See the table for links to the documentation on these properties.

Data Type	DisplayType	Type of Property
Vector	`'point'`	*line marker* On the MATLAB Line Properties reference page, under Line Property Descriptions, see Marker.

Data Type	DisplayType	Type of Property
	`'multipoint'`	*line marker* On the MATLAB Line Properties reference page, under Line Property Descriptions, see Marker.
	`'line'` (default)	*line* See the MATLAB Line Properties reference page.
	`'polygon'`	*patch* See the MATLAB Patch Properties reference page.
Image	`'image'`	*surface* See the MATLAB Surface Properties reference page.
Grid	`'surface'`	*surface* See the MATLAB Surface Properties reference page.
	`'mesh'`	*surface* See the MATLAB Surface Properties reference page.
	`'texturemap'`	*surface* See the MATLAB Surface Properties reference page.
	`'contour'`	*contour* See the Mapping Toolbox `contourm` reference page.

If `DisplayType` is `'texturemap'`, `geoshow` constructs a surface with `ZData` values set to 0.

When using the `filename` argument, the `DisplayType` parameter is automatically set, according to the following table:

Format	DisplayType
Shape file	`'point'`, `'line'`, or `'polygon'`
GeoTIFF	`'image'`
TIFF/JPEG/PNG with a world file	`'image'`
ARC ASCII GRID	`'surface'` (can be overridden)
SDTS raster	`'surface'` (can be overridden)

Output Arguments

h

Handle to a MATLAB graphics object or, in the case of polygons, a modified patch object. If a geostruct or shapefile name is input, `geoshow` returns the handle to an hggroup object with one child per feature in the geostruct or shapefile, excluding any features that are completely trimmed away. In the case of a polygon geostruct or shapefile, each child is a modified patch object; otherwise it is a line object.

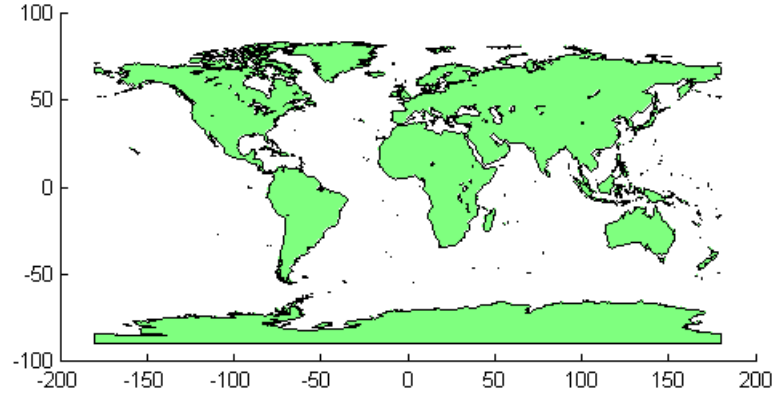
Class Support

Display Type	Supported Class Types
Image	`logical`, `uint8`, `uint16`, and `double`
Surface	`single` and `double`
Texture map	All numeric types and `logical`

Examples

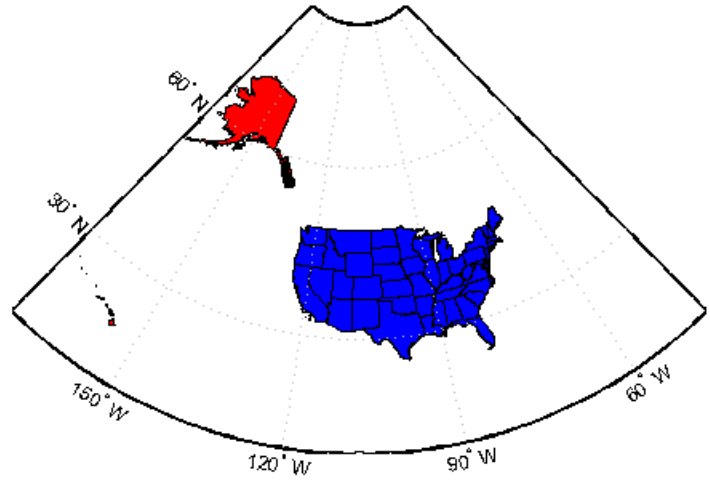
Display world land areas using a default Plate Carree projection:

```
figure
geoshow('landareas.shp', 'FaceColor', [0.5 1.0 0.5]);
```



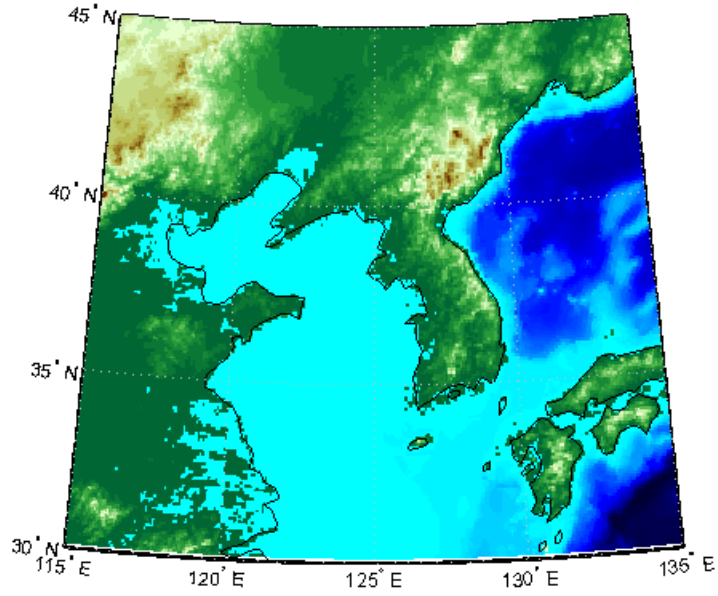
Override the symbolspec default rule:

```
% Create a worldmap of North America.
figure
worldmap('na');

% Read the USA high resolution data.
states = shaperead('usastatehi', 'UseGeoCoords', true);

% Create a symbolspec to make Alaska and Hawaii polygons red.
symspec = makesymbolspec('Polygon', ...
   {'Name', 'Alaska', 'FaceColor', 'red'}, ...
   {'Name', 'Hawaii', 'FaceColor', 'red'});

% Display all the other states in blue.
geoshow(states, 'SymbolSpec', symspec, ...
   'DefaultFaceColor', 'blue', ...
   'DefaultEdgeColor', 'black');
```



Create a `worldmap` of Korea and display the `korea` data grid as a texture map:

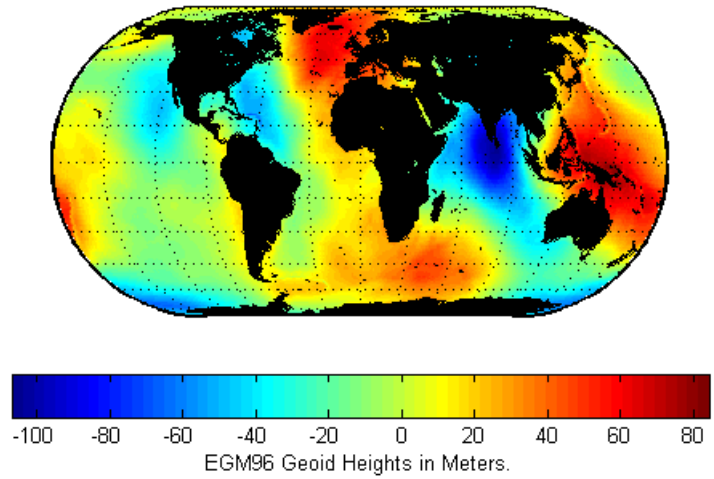
```
load korea
figure;
worldmap(map, refvec)

% Display the Korean data grid as a texture map.
geoshow(gca,map,refvec,'DisplayType','texturemap');
demcmap(map)

% Display the land area boundary as black lines.
S = shaperead('landareas','UseGeoCoords',true);
geoshow([S.Lat], [S.Lon],'Color','black');
```



Display the EGM96 geoid heights, masking out land areas:

```
load geoid
% Create a figure with an Eckert projection.
figure
axesm eckert4;
framem; gridm;
axis off

% Display the geoid as a texture map.
geoshow(geoid, geoidrefvec, 'DisplayType', 'texturemap');

% Create a colorbar and title.
hcb = colorbar('southoutside');
set(get(hcb,'Xlabel'),'String','EGM96 Geoid Heights in Meters.')
```

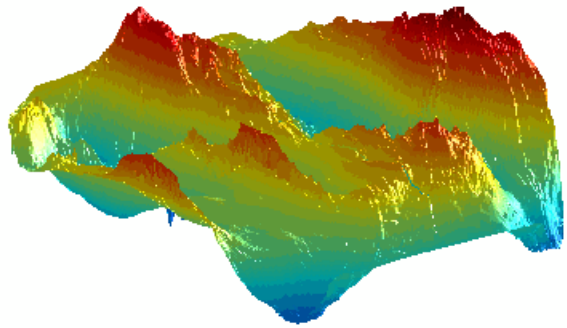
```
% Mask out all the land.
geoshow('landareas.shp', 'FaceColor', 'black');
```



Display the EGM96 geoid heights as a 3-D surface using the Eckert IV projection:

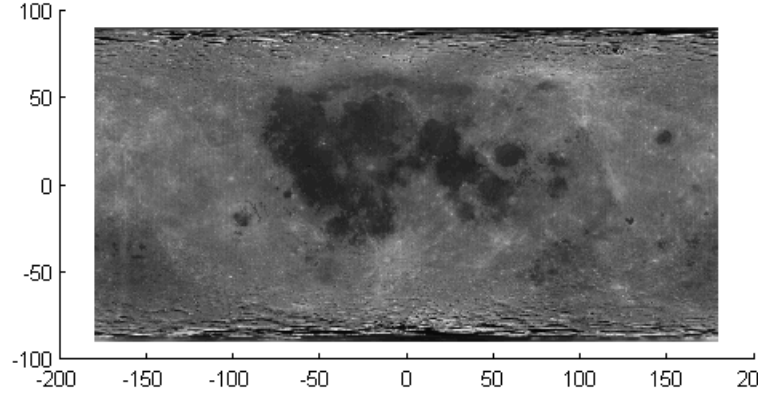
```
load geoid

% Create the figure with an Eckert projection.
figure
axesm eckert4;
axis off

% Display the geoid as a surface.
h = geoshow(geoid, geoidrefvec, 'DisplayType','surface');

% Add light and material.
light; material(0.6*[ 1 1 1]);

% View as a 3-D surface.
```

```
view(3)
axis normal
tightmap
```



Display the moon albedo image projected using Plate Carree and in an orthographic projection:

```
load moonalb

% Projection not specified. Uses Plate Carree.
figure
geoshow(moonalb,moonalbrefvec)
```

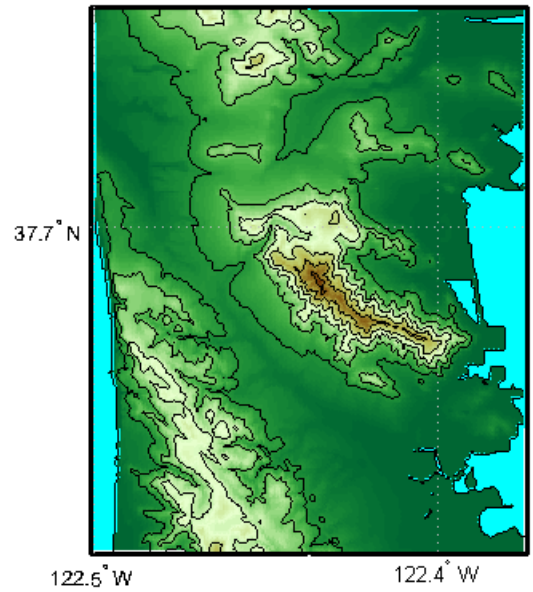



```
% Orthographic projection
figure
axesm ortho
geoshow(moonalb, moonalbrefvec, 'DisplayType', 'texturemap')
colormap(gray(256))
axis off
```

Read and display the San Francisco South 24K DEM data:

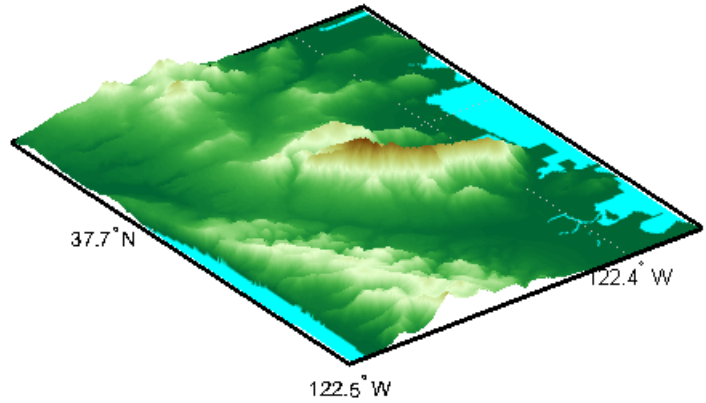
```
filenames = gunzip('sanfranciscos.dem.gz', tempdir);
demFilename = filenames{1};

% Read every point of the 1:24,000 DEM file.
[lat, lon,Z] = usgs24kdem(demFilename,2);

% Delete the temporary gunzipped file.
delete(demFilename);

% Move all points at sea level to -1 to color them blue.
Z(Z==0) = -1;

% Compute the latitude and longitude limits for the DEM.
latlim = [min(lat(:)) max(lat(:))];
lonlim = [min(lon(:)) max(lon(:))];
```

```
% Display the DEM values as a texture map.
figure
usamap(latlim, lonlim)
geoshow(lat, lon, Z, 'DisplayType','texturemap')
demcmap(Z)
daspectm('m',1)

% Overlay black contour lines onto the texturemap.
geoshow(lat, lon, Z, 'DisplayType', 'contour', ...
  'LineColor', 'black');
```




```
% View the DEM values in 3-D.
figure
usamap(latlim, lonlim)
geoshow(lat, lon, Z, 'DisplayType', 'surface')
```

```
demcmap(Z)
daspectm('m',1)
view(3)
```



See Also

`axesm` | `makesymbolspec` | `mapshow` | `mapview` | `updategeostruct`

How To

- "Displaying Vector Data with Mapping Toolbox Functions"
- "Understanding Raster Geodata"

Purpose

Convert GeoTIFF information to map projection structure

Syntax

```
mstruct = geotiff2mstruct(proj)
```

Description

`mstruct = geotiff2mstruct(proj)` converts the GeoTIFF projection structure, `proj`, to the map projection structure, `mstruct`. The unit of length of the `mstruct` projection is meter.

The GeoTIFF projection structure, `proj`, must reference a projected coordinate system, as indicated by a value of `'ModelTypeProjected'` in the `ModelType` field. If `ModelType` has the value `'ModelTypeGeographic'` then it doesn't make sense to convert to a map projection structure and an error is issued.

Examples

```
% Compare inverse transform of points using projinv and minvtran.
% Obtain the projection structure of 'boston.tif'.
proj = geotiffinfo('boston.tif');

% Convert the corner map coordinates to latitude and longitude.
x = proj.CornerCoords.X;
y = proj.CornerCoords.Y;
[latProj, lonProj] = projinv(proj, x, y);

% Obtain the mstruct from the GeoTIFF projection.
mstruct = geotiff2mstruct(proj);

% Convert the units of x and y to meter to match projection units.
x = unitsratio('meter','sf') * x;
y = unitsratio('meter','sf') * y;

% Convert the corner map coordinates to latitude and longitude.
[latMstruct, lonMstruct] = minvtran(mstruct, x, y);

% Verify the values are within a tolerance of each other.
abs(latProj - latMstruct) <= 1e-7
abs(lonProj - lonMstruct) <= 1e-7
```

```
ans =
     1     1     1     1

ans =
     1     1     1     1
```

See Also

axesm | defaultm | geotiffinfo | projfwd | projinv | projlist

Purpose

Information about GeoTIFF file

Syntax

```
info = geotiffinfo(filename)
info = geotiffinfo(url)
```

Description

`info = geotiffinfo(filename)` returns a structure whose fields contain image properties and cartographic information about a GeoTIFF file.

`info = geotiffinfo(url)` reads the GeoTIFF image from a URL.

Input Arguments

filename

String that specifies the name of the GeoTIFF file. Include the folder name in `filename` or place the file in the current folder or in a folder on the MATLAB path. If the named file includes the extension `.TIF` or `.TIFF` (either upper- or lowercase), you can omit the extension from `filename`.

If the named file contains multiple GeoTIFF images, `info` is a structure array with one element for each image in the file. For example, `info(3)` would contain information about the third image in the file. If multiple images exist in the file, it is assumed that each image has the same cartographic information and image width and height.

url

URL that includes the protocol type (e.g., "`http://`").

Output Arguments

info

Structure whose fields contain image properties and cartographic information about a GeoTIFF file. The `info` structure contains these fields:

`Filename`	String containing the name of the file or URL.
`FileModDate`	String containing the modification date of the file.

`FileSize`	Integer indicating the size of the file in bytes.
`Format`	String containing the file format, which should always be `'tiff'`.
`FormatVersion`	String or number specifying the file format version.
`Height`	Integer indicating the height of the image in pixels.
`Width`	Integer indicating the width of the image in pixels.
`BitDepth`	Integer indicating the number of bits per pixel.
`ColorType`	String indicating the type of image: `'truecolor'` for a true-color (RGB) image, `'grayscale'` for a grayscale image, or `'indexed'` for an indexed image.
`ModelType`	String indicating the type of coordinate system used to georeference the image: `'ModelTypeProjected'`, `'ModelTypeGeographic'`, `'ModelTypeGeocentric'`, or `''`.
`PCS`	String indicating the projected coordinate system.
`Projection`	String describing the EPSG identifier for the underlying projection method.
`MapSys`	String indicating the map system, if applicable: `'STATE_PLANE_27'`, `'STATE_PLANE_83'`, `'UTM_NORTH'`, `'UTM_SOUTH'`, or `''`.
`Zone`	Double indicating the UTM or State Plane Zone number, empty (`[]`) if not applicable or unknown.
`CTProjection`	String containing the GeoTIFF identifier for the underlying projection method.

`ProjParm` — N-by-1 double containing projection parameter values. The identity of each element is specified by the corresponding element of `ProjParmId`. Lengths are in meters, angles in decimal degrees.

`ProjParmId` — N-by-1 cell array listing the projection parameter identifier for each corresponding numerical element of `ProjParm`:

Projection Parameter Identifiers

- `'ProjNatOriginLatGeoKey'`
- `'ProjNatOriginLongGeoKey'`
- `'ProjFalseEastingGeoKey'`
- `'ProjFalseNorthingGeoKey'`
- `'ProjFalseOriginLatGeoKey'`
- `'ProjFalseOriginLongGeoKey'`
- `'ProjCenterLatGeoKey'`
- `'ProjCenterLongGeoKey'`
- `'ProjAzimuthAngleGeoKey'`
- `'ProjRectifiedGridAngleGeoKey'`
- `'ProjScaleAtNatOriginGeoKey'`
- `'ProjStdParallel1GeoKey'`
- `'ProjStdParallel2GeoKey'`

`GCS` — String indicating the geographic coordinate system.

`Datum` — String indicating the projection datum type, such as `'North American Datum 1927'` or `'North American Datum 1983'`.

`Ellipsoid`	String indicating the ellipsoid name as defined by the `ellipsoid.csv` EPSG file.
`SemiMajor`	Double indicating the length of the semimajor axis of the ellipsoid, in meters.
`SemiMinor`	Double indicating the length of the semiminor axis of the ellipsoid, in meters.
`PM`	String indicating the prime meridian location, for example, `'Greenwich'` or `'Paris'`.
`PmLongToGreenwich`	Double indicating the decimal degrees of longitude between this prime meridian and Greenwich. Prime meridians to the west of Greenwich are negative.
`UOMLength`	String indicating the units of length used in the projected coordinate system.
`UOMLengthInMeters`	Double defining the `UOMLength` unit in meters.
`UOMAngle`	String indicating the angular units used for geographic coordinates.
`UOMAngleInDegrees`	Double defining the `UOMAngle` unit in degrees.
`TiePoints`	Structure containing the image tiepoints. The structure contains these fields: • `ImagePoints` — Structure containing row and column coordinates of each image tiepoint. The `ImagePoints` structure contains these fields: **Fields in ImagePoints Structure** `Row` — Double array of size 1-by-N. `Col` — Double array of size 1-by-N.

- `WorldPoints` — Structure containing the *x* and *y* world coordinates of the tiepoints. The `WorldPoints` structure contains these fields:

  Fields in WorldPoints Structure

  `X` — Double array of size 1-by-N.

  `Y` — Double array of size 1-by-N.

`PixelScale` — 3-by-1 double array that specifies the X, Y, Z pixel scale values.

`SpatialRef` — `spatialref.MapRasterReference` object if `ModelType` is `'ModelTypeProjected'`, or a `spatialref.GeoRasterReference` object if `ModelType` is `'ModelTypeGeographic'`. If `ModelType` is empty, a warning is issued and `SpatialRef` is a `spatialref.MapRasterReference` object. `SpatialRef` is empty if `ModelType` is `'ModelTypeGeocentric'`, if the spatial referencing is ambiguously defined by the GeoTiff file, or if `ModelType` is `'ModelTypeGeographic'` and the geometric transformation type is `'affine'`.

`RefMatrix` — 3-by-2 double referencing matrix that must be unambiguously defined by the GeoTIFF file. Otherwise it is empty (`[]`).

`BoundingBox` — 2-by-2 double array that specifies the minimum (row 1) and maximum (row 2) values for each dimension of the image data in the GeoTIFF file.

`CornerCoords` Structure with six fields that contains coordinates of the outer corners of the GeoTIFF image. Each field is a 1-by-4 double array, or empty (`[]`) if unknown. The arrays contain the coordinates of the outer corners of the corner pixels, starting from the `(1,1)` corner and proceeding clockwise:

Coordinates of the Outer Corners

- X — Easting coordinates in the projected coordinate system. `X` equals `Lon` (below) if *`ModelType`* is `'ModelTypeGeographic'`
- Y — Northing coordinates in the projected coordinate system. `Y` equals `Lat` (below) if *`ModelType`* is `'ModelTypeGeographic'`
- `Row` — Row coordinates of the corner.
- `Col` — Column coordinates of the corner.
- `Lat` — Latitudes of the corner.
- `Lon` — Longitudes of the corner.

`GeoTIFFCodes` Structure containing raw numeric values for those GeoTIFF fields that are encoded numerically in the file. These raw values, converted to a string elsewhere in the `info` structure, are provided here for reference.

GeoTIFFCodes Fields

- `Model`
- `PCS`
- `GCS`
- `UOMLength`
- `UOMAngle`

- `Datum`
- `PM`
- `Ellipsoid`
- `ProjCode`
- `Projection`
- `CTProjection`
- `ProjParmId`
- `MapSys`

Each is scalar, except for `ProjParmId`, which is a column vector.

`GeoTIFFTags` Structure containing field names that match the GeoTIFF tags in the file. At least one GeoTIFF tag must be present in the file or an error is issued. The following fields may be included:

GeoTIFF Tag Fields

- `ModelPixelScaleTag`: 1-by-3 `double`
- `ModelTiepointTag`: 1-by-6 `double`
- `ModelTransformationTag`: 1-by-16 `double`
- `GeoKeyDirectoryTag`: scalar structure
- `GeoAsciiParamsTag`: string
- `GeoDoubleParamsTag`: 1-by-N `double`

The `GeoKeyDirectoryTag` contains field names that match the names of the "GeoKeys". For

	more information about the "GeoKeys" refer to the GeoTIFF specification.
`ImageDescription`	String describing the image. If no description is included in the file, the field is omitted.

Examples

Return information about the `boston.tif` file:

```
info = geotiffinfo('boston.tif')

info =
             Filename: [1x76 char]
          FileModDate: '24-May-2007 11:08:15'
             FileSize: 38729900
               Format: 'tif'
        FormatVersion: []
               Height: 2881
                Width: 4481
             BitDepth: 8
            ColorType: 'truecolor'
            ModelType: 'ModelTypeProjected'
                  PCS: 'NAD83 / Massachusetts Mainland'
           Projection: 'SPCS83 Massachusetts Mainland zone (meters)'
               MapSys: 'STATE_PLANE_83'
                 Zone: 2001
         CTProjection: 'CT_LambertConfConic_2SP'
             ProjParm: [7x1 double]
           ProjParmId: {7x1 cell}
                  GCS: 'NAD83'
                Datum: 'North American Datum 1983'
           Ellipsoid: 'GRS 1980'
           SemiMajor: 6378137
           SemiMinor: 6.3568e+006
                  PM: 'Greenwich'
    PMLongToGreenwich: 0
            UOMLength: 'US survey foot'
    UOMLengthInMeters: 0.3048
```

```
                UOMAngle: 'degree'
       UOMAngleInDegrees: 1
              TiePoints: [1x1 struct]
             PixelScale: [3x1 double]
             SpatialRef: [1x1 spatialref.MapRasterReference]
              RefMatrix: [3x2 double]
            BoundingBox: [2x2 double]
           CornerCoords: [1x1 struct]
           GeoTIFFCodes: [1x1 struct]
            GeoTIFFTags: [1x1 struct]
       ImageDescription: '"GeoEye"'
```

See Also

geotiffread | geotiffwrite | projfwd | projinv | projlist

geotiffread

Purpose

Read GeoTIFF file

Syntax

```
[A, R] = geotiffread(filename)
[X, cmap, R] = geotiffread(filename)
[A, refmat, bbox] = geotiffread(filename)
[X, cmap, refmat, bbox] = geotiffread(filename)
[...] = geotiffread(filename, idx)
[...] = geotiffread(url, ...)
```

Description

`[A, R] = geotiffread(filename)` reads a georeferenced grayscale, RGB, or multispectral image or data grid from the GeoTIFF file specified by `filename` into `A` and constructs a spatial referencing object, `R`.

`[X, cmap, R] = geotiffread(filename)` reads an indexed image into `X` and the associated colormap into `cmap`, and constructs a spatial referencing object, `R`. Colormap values in the image file are rescaled into the range [0,1].

`[A, refmat, bbox] = geotiffread(filename)` reads a georeferenced grayscale, RGB, or multispectral image or data grid into `A`; the corresponding referencing matrix into `refmat`; and the bounding box into `bbox`.

`[X, cmap, refmat, bbox] = geotiffread(filename)` reads an indexed image into `X`, the associated colormap into `cmap`, the referencing matrix into `refmat`, and the bounding box into `bbox`. The referencing matrix must be unambiguously defined by the GeoTIFF file, otherwise it and the bounding box are returned empty.

`[...] = geotiffread(filename, idx)` reads one image from a multi-image GeoTIFF file.

`[...] = geotiffread(url, ...)` reads the GeoTIFF image from a URL.

Tips

- `geotiffread` imports pixel data using the TIFF-reading capabilities of the MATLAB function `imread` and likewise shares any limitations of `imread`. Consult the `imread` documentation for information on TIFF image support.

Input Arguments

filename

String that specifies the name of the GeoTIFF file. `filename` can include the folder name. Otherwise, the file must be in the current folder or in a folder on the MATLAB path. If the named file includes the extension `'.TIF'` or `'.TIFF'` (either upper or lowercase), you can omit the extension from `filename`.

idx

Integer value that specifies the order that the image appears in the file. For example, if `idx` is 3, `geotiffread` reads the third image in the file.

Default: First image in the file

url

Internet URL. The URL must include the protocol type (e.g., "http://").

Output Arguments

A

Two-dimensional array, if the file contains a grayscale image or data grid. An M-by-N-by-P array, if the file contains a color image, multispectral image, hyperspectral image, or data grid. The class of `A` depends on the storage class of the pixel data in the file, which is related to the `BitsPerSample` property as returned by the `imfinfo` function.

R

`spatialref.GeoRasterReference` object if the image or data grid is referenced to a geographic coordinate system, or a `spatialref.MapRasterReference` object if it is referenced to a projected coordinate system.

X

Indexed image

cmap

Colormap

refmat

Referencing matrix

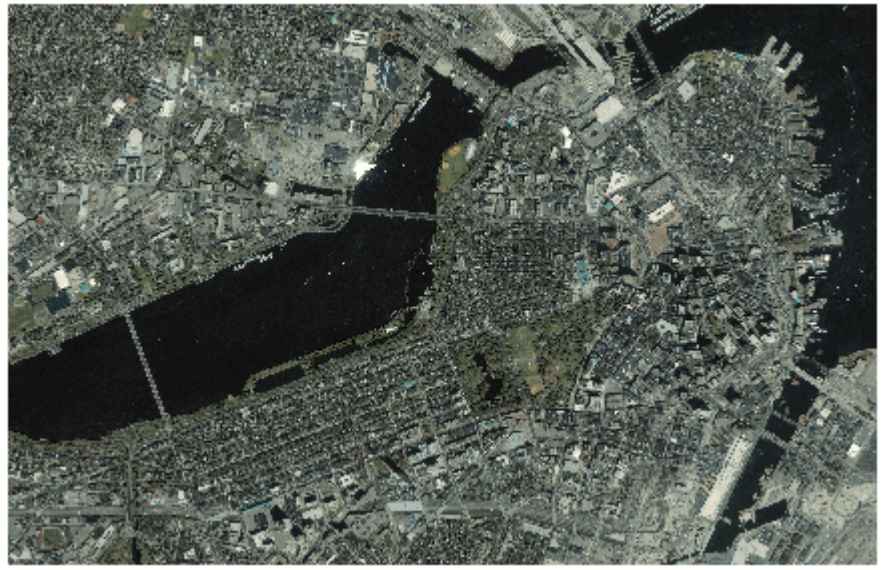
bbox

Bounding box

Examples

Read and display the Boston GeoTIFF image:

```
[boston, R] = geotiffread('boston.tif');
figure
mapshow(boston, R);
axis image off
```



boston.tif copyright © GeoEye™, all rights reserved.

See Also

geoshow | geotiffinfo | geotiffwrite | imread | mapshow

geotiffwrite

Purpose

Write GeoTIFF file

Syntax

```
geotiffwrite(filename,A,R)
geotiffwrite(filename,X,cmap,R)
geotiffwrite(...,Name,Value)
```

Description

`geotiffwrite(filename,A,R)` writes a georeferenced image or data grid, `A`, spatially referenced by `R`, into an output file, `filename`.

`geotiffwrite(filename,X,cmap,R)` writes the indexed image in `X` and its associated colormap, `cmap`, to `filename`. `X` is spatially referenced by `R`.

`geotiffwrite(...,Name,Value)` writes a georeferenced image or data grid with additional options that control various characteristics of the output file specified by one or more `Name,Value` pair arguments.

Tips

- If you are working with image coordinates in a projected coordinate system and `R` is a `spatialref.MapRasterReference` object or a referencing matrix, set the `'GeoKeyDirectoryTag'` or `'CoordRefSysCode'` argument, accordingly. See "Name-Value Pair Arguments" on page 3-491 for more information.

Input Arguments

filename

Character string that specifies the output file name and location. If your `filename` includes an extension, it must be `'.tif'` or `'.TIF'`. The output file is a tiled GeoTIFF file if the input, `A`, is at least 160-by-160 in size. Otherwise, the output file is organized as rows-per-strip.

A

M-by-N array (grayscale image or data grid) or M-by-N-by-P array (color or hyperspectral image, or data grid). The coordinates of `A` are geographic and in the `'WGS 84'` coordinate system, unless you specify `'GeoKeyDirectoryTag'` or `'CoordRefSysCode'` and indicate a different coordinate system.

R

`spatialref.GeoRasterReference` object, referencing matrix, or referencing vector; or `spatialref.MapRasterReference` object or referencing matrix. Provides spatial referencing information.

X

Indexed image

cmap

Colormap

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

The argument names are case insensitive.

CoordRefSysCode

Scalar, positive, integer-valued number that specifies the coordinate reference system code for the coordinates of the data. You can specify coordinates in either a geographic or a projected coordinate system, and you can use a string, such as `'EPSG:4326'`. If you specify the coordinate system with a string, include the `'EPSG:'` prefix. See “References” on page 3-501 for a link to the GeoTiff Specification or the EPSG data files (`pcs.csv` and `gcs.csv`) for the code numbers.

If you specify both the `'GeoKeyDirectoryTag'` and the `'CoordRefSysCode'`, the coordinate system code in the `'CoordRefSysCode'` takes precedence over the coordinate system key found in the `'GeoKeyDirectoryTag'`. If one value specifies a geographic coordinate system and the other value specifies a projected coordinate system, you receive an error.

If you do not specify a value for this argument, the default value is 4326, indicating that the coordinates are geographic and in the `'WGS 84'` geographic coordinate system.

Default: 4326

GeoKeyDirectoryTag

Structure that specifies the GeoTIFF coordinate reference system and meta-information. The structure contains field names that match the GeoKey names in the GeoTIFF specification. The field names are case insensitive. The structure can be obtained from the GeoTIFF information structure, returned by `geotiffinfo`, in the field, `GeoTIFFTags.GeoKeyDirectoryTag`. If you set certain fields of the `'GeoKeyDirectoryTag'` to inconsistent settings, you receive an error message.

The `GTRasterTypeGeoKey` field is ignored, if specified. The value for this GeoKey is derived from `R`. If you set certain fields of the `'GeoKeyDirectoryTag'` to inconsistent settings, you receive an error message. For instance, if `R` is either a `spatialref.GeoRasterReference` object or a refvec and you specify a `ProjectedCSTypeGeoKey` field or you set the `GTModelTypeGeoKey` field to 1 (projected coordinate system), you receive an error. Likewise, if `R` is a `spatialref.MapRasterReference` object and you do not specify a `ProjectedCSTypeGeoKey` field or a `'CoordRefSysCode'`, or the `GTModelTypeGeoKey` field is set to 2 (geographic coordinate system), you receive an error message.

TiffTags

Structure that specifies values for the TIFF tags in the output file. The field names of the structure match the TIFF tag names supported by the Tiff class. The field names are case insensitive.

You cannot set most TIFF tags using the structure input.

TiffTags Exceptions

- `BitsPerSample`

- SampleFormat
- SamplesPerPixel
- StripByteCounts
- StripOffsets
- SubFileType
- SubIFD
- TileByteCounts
- TileOffsets
- ColorMap
- ImageLength
- ImageWidth
- GeoAsciiParamsTag
- GeoDoubleParamsTag
- GeoKeyDirectoryTag
- ModelPixelScaleTag
- ModelTiepointTag
- ModelTransformationTag

The function sets several TIFF tags. The field names corresponding to the TIFF tag, their corresponding field values set by the function, their permissible values (if different from the Tiff class), and their data type are noted in the following table.

Automatic TIFF Tags

Field Name	Description
`Compression`	String indicating the type of image compression. The default is `'PackBits'`. Other permissible values are `'LZW'`, `'Deflate'`, and `'none'`. Numeric values, `Tiff.Compression.LZW`, `Tiff.Compression.PackBits`, `Tiff.Compression.Deflate`, or `Tiff.Compression.None` can also be used.
`PhotometricInterpretation`	String indicating the type of photometric interpretation. The field name can be shortened to `Photometric`. The value is set based on the input image characteristic, using the following algorithm: If `A` is `[M-by-N-by-3]` and is class type `uint8` or `uint16`, then the value is `'RGB'`. For all other sizes and data types, the value is `'MinIsBlack'`. If the `X, CMAP` syntax is supplied, the value is `'Palette'`. If the value is set to `'RGB'` and `A` is not `[M-by-N-by-3]`, an error is issued. Permissible values are `'MinIsBlack'`, `'RGB'`, `'Palette'`, `'Separated'`. The numeric values, `Tiff.Photometric.MinIsBlack`, `Tiff.Photometric.RGB`, `Tiff.Photometric.Palette`, `Tiff.Photometric.Separated` can also be used.
`Software`	A string indicating the software maker of the file. The value is set to the string value `'MATLAB, Mapping Toolbox, The MathWorks, Inc.'`. To remove the value, set the tag to the empty string (`''`).
`RowsPerStrip`	A scalar positive integer-valued number specifying the desired rows per strip in the output file. `RowsPerStrip` is set to the value of 1 if the size of A is less than `[160-by-160]`. An error is issued if both `RowsPerStrip` and `TileWidth` and/or `TileLength` are specified.

Field Name	Description
TileWidth	A scalar positive integer-valued number and a multiple of 16 specifying the width of the tiles. TileWidth is set if the size of A is greater than [160-by-160]. If so, the value is such that a maximum of [10-by-10] tiles are created. An error is issued if both RowsPerStrip and TileWidth are specified.
TileLength	A scalar positive integer-valued number and a multiple of 16 specifying the length of the tiles. TileLength is set if the size of A is greater than [160-by-160]. If so, the value is such that a maximum of [10-by-10] tiles are created. An error is issued if both RowsPerStrip and TileLength are specified.

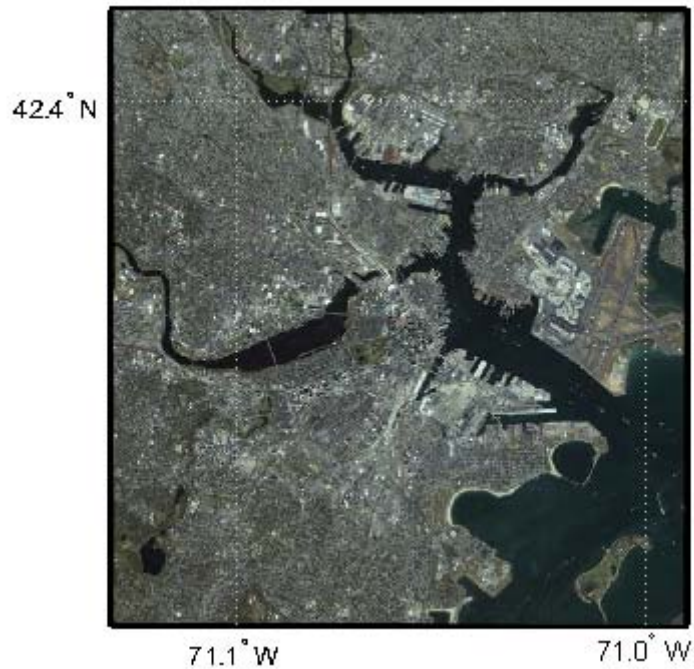
Class Support

The input array, A, can be any numeric class or logical. The indexed image, X, must be class uint8 or uint16. The colormap array, cmap, must be class double.

Examples

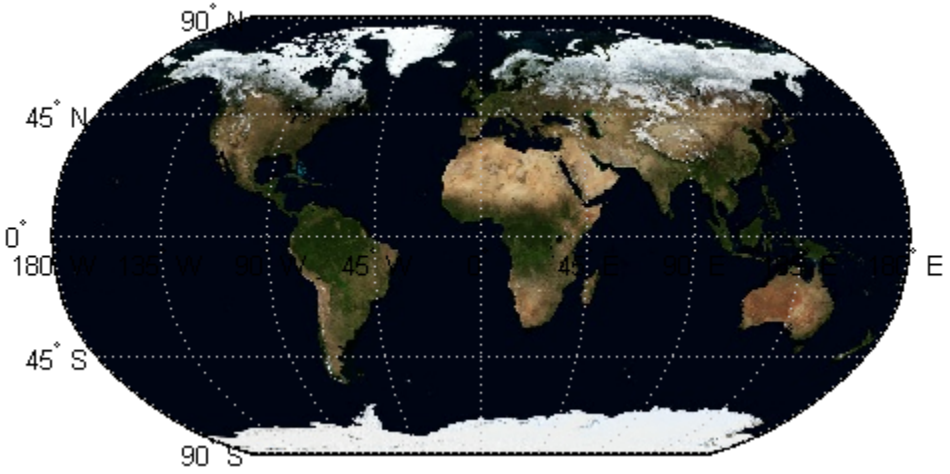
Write an image with geographic coordinates from a JPEG file to a GeoTIFF file:

```
basename = 'boston_ovr';
imagefile = [basename '.jpg'];
RGB = imread(imagefile);
worldfile = getworldfilename(imagefile);
R = worldfileread(worldfile, 'geographic', size(RGB));
filename = [basename '.tif'];
geotiffwrite(filename, RGB, R)
figure
usamap(RGB, R)
geoshow(filename)
```



Write a WMS image to a GeoTIFF file:

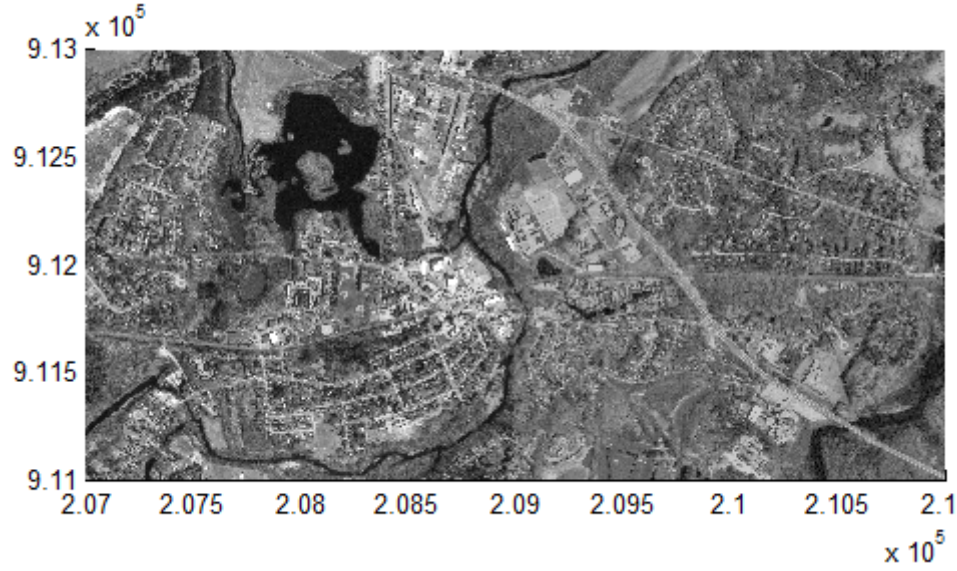
```
nasa = wmsfind('nasa', 'SearchField', 'serverurl');
layerName = 'bluemarbleng';
layer = nasa.refine(layerName,  'SearchField', 'layername', ...
  'MatchType', 'exact');
[A, R] = wmsread(layer(1));
filename = [layerName '.tif'];
geotiffwrite(filename, A, R)
figure
worldmap world
geoshow(filename)
```



Write the Concord orthophotos to a single GeoTIFF file:

```
% Read the two adjacent orthophotos and combine them.
X_west = imread('concord_ortho_w.tif');
X_east = imread('concord_ortho_e.tif');
X = [X_west X_east];

% Construct referencing objects for the orthophotos and for their
% combination.
R_west = worldfileread('concord_ortho_w.tfw', 'planar', size(X_west));
R_east = worldfileread('concord_ortho_e.tfw', 'planar', size(X_east));
R = R_west;
R.XLimWorld = [R_west.XLimWorld(1) R_east.XLimWorld(2)];
R.RasterSize = size(X);

% Write the combined image to a GeoTIFF file. Use the code number,
% 26986, indicating the PCS_NAD83_Massachusetts Projected Coordinate
% System.
coordRefSysCode = 26986;
```

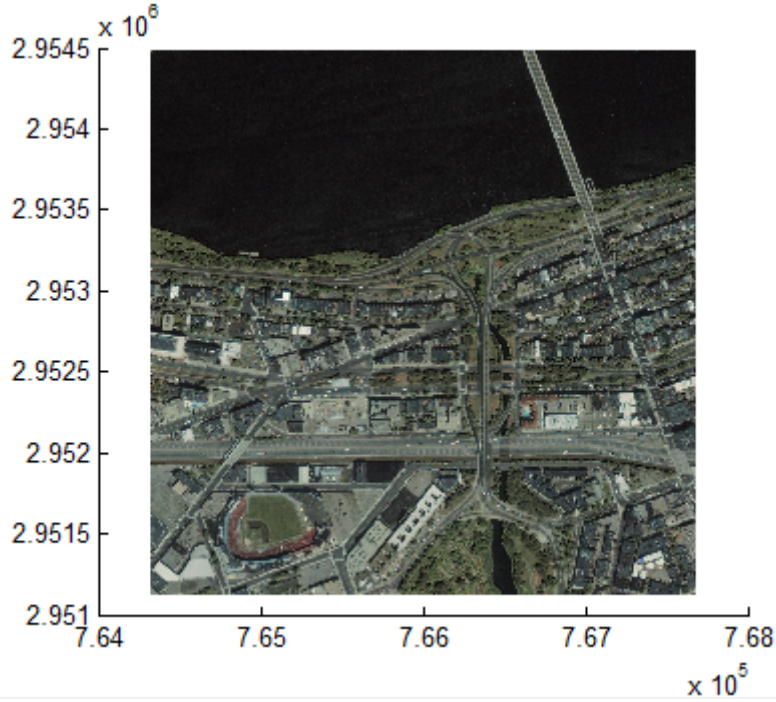
```
filename = 'concord_ortho.tif';
geotiffwrite(filename, X, R, 'CoordRefSysCode', coordRefSysCode);
figure
mapshow(filename)
```



Write the first 1024 columns and last 1024 rows of a GeoTIFF file to a new GeoTIFF file:

```
[A, R] = geotiffread('boston.tif');
row = [size(A,1)-1024+1 size(A,1)];
col = [1 1024];
subImage = A(row(1):row(2), col(1):col(2), :);
xi = col + [-.5 .5];
yi = row + [-.5 .5];
[xlim, ylim] = R.intrinsicToWorld(xi, yi);
subR = R;
subR.RasterSize = size(subImage);
```

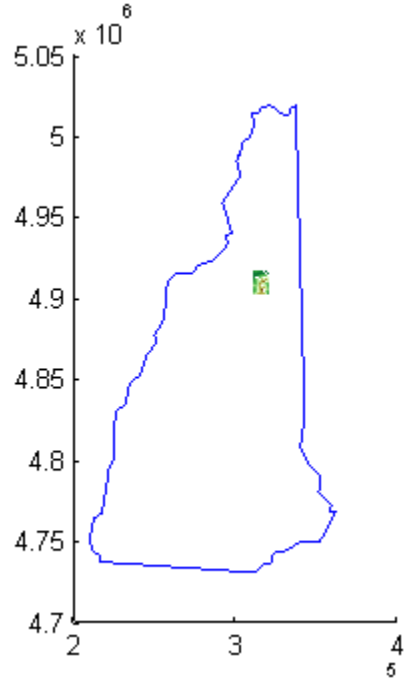
```
subR.XLimWorld = sort(xlim);
subR.YLimWorld = sort(ylim);
info = geotiffinfo('boston.tif');
filename = 'boston_subimage.tif';
geotiffwrite(filename, subImage, subR,  ...
'GeoKeyDirectoryTag', info.GeoTIFFTags.GeoKeyDirectoryTag);
figure
mapshow(filename);
```



Write the Mount Washington SDTS DEM terrain data to GeoTIFF. The data are referenced to Universal Transverse Mercator (UTM), Zone 19, in the North American Datum of 1927. This corresponds to the GeoTIFF PCS_NAD27_UTM_zone_19N code number 26719. Set the

raster interpretation to 'postings' because the data is USGS DEM. This corresponds to the GeoTIFF raster type PixelIsPoint.

```
[Z, refmat] = sdtsdemread('9129CATD.ddf');
R = refmatToMapRasterReference(refmat, size(Z));
R.RasterInterpretation = 'postings';
key.GTModelTypeGeoKey  = 1;  % Projected Coordinate System (PCS)
key.GTRasterTypeGeoKey = 2;  % PixelIsPoint
key.ProjectedCSTypeGeoKey = 26719;
filename = '9129.tif';
geotiffwrite(filename, Z, R, 'GeoKeyDirectoryTag', key);

% Plot the outline of the state of New Hampshire in UTM.
S = shaperead('usastatelo', 'UseGeoCoords', true, 'Selector',...
    {@(name) any(strcmp(name,{'New Hampshire'})), 'Name'});
proj = geotiffinfo(filename);
[x, y] = projfwd(proj, [S.Lat], [S.Lon]);
figure
mapshow(x,y)

% Display the GeoTIFF DEM file.
hold on
h = mapshow(filename, 'DisplayType', 'surface');
demcmap(get(h,'ZData'))
```



References

Check the GeoTIFF specification for values of the following parameters:

- `'CoordRefSysCode'` value for geographic coordinate systems
- `'CoordRefSysCode'` value for projected coordinate systems
- GeoKey field names for the `'GeoKeyDirectoryTag'`

The `'CoordRefSysCode'` values may also be obtained from the EPSG data files (`pcs.csv` and `gcs.csv`) in the folder:

`matlabroot``/toolbox/map/mapproj/projdata/epsg_csv`

See Also

`geotiffinfo` | `geotiffread` | `imread` | `imwrite` | `Tiff`.

getm

Purpose

Map object properties

Syntax

```
mat = getm(h)
mat = getm(h,MapPropertyName)
getm('MapProjection')
getm('axes')
getm('units')
```

Description

`mat = getm(h)` returns the map structure of the map axes specified by its handle. If the handle of a child of the map axes is specified, only its properties are returned.

`mat = getm(h,MapPropertyName)` returns the specified property value.

`getm('MapProjection')` lists all available projections.

`getm('axes')` lists the map axes properties by property name.

`getm('units')` lists the available units.

Examples

Create a default map axes and query a property value:

```
axesm('mercator','AngleUnits','degrees')
getm(gca,'MapParallels')

ans =
     0
```

See Also

`axesm | setm`

Purpose

Interactively assign seeds for data grid encoding

Syntax

```
[row,col,val] = getseeds(map,R,nseeds)
[row,col,val] = getseeds(map,R,nseeds,seedval)
mat = getseeds(...)
```

Description

`[row,col,val] = getseeds(map,R,nseeds)` allows user to identify geographical objects while customizing a raster map. It prompts the user for mouse click positions of objects and assigns them a code value. The user is prompted for the value to seed at each location. The outputs are the row and column of the seed location and the value assigned at that location. `R` is either a 1-by-3 vector containing elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

or a 3-by-2 referencing matrix that transforms raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel.

`[row,col,val] = getseeds(map,R,nseeds,seedval)` assigns the value `seedval` to each location supplied. If `seedval` is a scalar then the same value is assigned at each location. Otherwise, if `seedval` is a vector it must be `length(nseeds)` and each entry is assigned to the corresponding location. `getseeds` operates on the current axes (`gca`).

`mat = getseeds(...)` returns a single output matrix where `mat = [row col val]`.

Examples

Demonstrate this for yourself by typing the following and interactively selecting points:

```
load topo
axesm('gortho','grid','on')
```

```
seedmat = getseeds(topo,topolegend,3)
```

When you have selected three points, you are prompted for their values. The regular data grid need not be displayed to execute `getseeds` on it.

See Also

`encodem`

Purpose

Derive worldfile name from image filename

Syntax

```
worldfilename = getworldfilename(imagefilename)
```

Description

`worldfilename = getworldfilename(imagefilename)` returns the name of the corresponding worldfile derived from the name of an image file.

The worldfile and the image file have the same base name. If `imagefilename` follows the ".3" convention, then you create the worldfile extension by removing the middle letter and appending the letter `'w'`.

If `imagefilename` has an extension that does not follow the ".3" convention, then a `'w'` is appended to the full image name to construct the worldfile name.

If `imagefilename` has no extension, then `'.wld'` is appended to construct a worldfile name.

Examples

Given the following image filenames, `worldfilename` would return these worldfile names:

Image File Name	Worldfile Name
`myimage.tif`	`myimage.tfw`
`myimage.jpeg`	`myimage.jpegw`
`myimage`	`myimage.wld`

See Also

`mapshow` | `mapview` | `worldfileread` | `worldfilewrite`

globedem

Purpose

Read Global Land One-km Base Elevation (GLOBE) data

Syntax

```
[Z,refvec] = globedem(filename,scalefactor)
[Z,refvec] = globedem(filename,scalefactor,latlim,lonlim)
[Z,refvec] = globedem(foldername,scalefactor,latlim,lonlim)
```

Description

`[Z,refvec] = globedem(filename,scalefactor)` reads the GLOBE DEM files and returns the result as a regular data grid. The filename is given as a string that does not include an extension. GLOBEDEM first reads the ESRI header file found in the subfolder `'/esri/hdr/'` and then the binary data file filename. If the files are not found on the MATLAB path, they can be selected interactively. `scalefactor` is an integer that when equal to 1 gives the data at its full resolution. When `scalefactor` is an integer `n` larger than 1, every `n`th point is returned. The map data is returned as an array of elevations and associated three-element referencing vector. Elevations are given in meters above mean sea level, using WGS 84 as a horizontal datum.

`[Z,refvec] = globedem(filename,scalefactor,latlim,lonlim)` allows a subset of the map data to be read. The limits of the desired data are specified as vectors of latitude and longitude in degrees. The elements of `latlim` and `lonlim` must be in ascending order.

`[Z,refvec] = globedem(foldername,scalefactor,latlim,lonlim)` reads and concatenates data from multiple files within a GLOBE folder tree. The `foldername` input is a string with the name of the folder that contains both the uncompressed data files and the ESRI header files.

Background

GLOBE, the Global Land One-km Base Elevation data, was compiled by the National Geophysical Data Center from more than 10 different sources of gridded elevation data. GLOBE can be considered a higher resolution successor to TerrainBase. The data set consists of 16 tiles, each covering 50 by 90 degrees. Tiles require as much as 60 MB of storage. Uncompressed tiles take between 100 and 130 MB.

Tips

The `globedem` function reads data from GLOBE Version 1.0. The data is for elevations only. Elevations are given in meters above mean sea

level using WGS 84 as a horizontal datum. Areas with no data, such as the oceans, are coded with NaNs.

The data set and documentation are available over the Internet.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: http://www.mathworks.com/help/map/finding-geospatial-data.html .

Examples

Determine the file that contains the area around Cape Cod.

```
latlim = [41 42.5]; lonlim = [-73 -69.9];
globedems(latlim,lonlim)

ans =
    'f10g'
```

Extract every 20th point from the tile covering the northeastern United States and eastern Canada. Provide an empty file name, and select the file interactively.

```
[Z,refvec] = globedem([],20);
size(Z)

ans =
   300   540
```

Extract a subset of the data for Massachusetts at the full resolution.

```
latlim = [41 42.5]; lonlim = [-73 -69.9];
[Z,refvec] = globedem('f10g',1,latlim,lonlim);
size(Z)

ans =
   181 373
```

Replace the NaNs in the ocean with -1 to color them blue.

```
Z(isnan(Z)) = -1;
```

Extract some data for southern Louisiana in an area that straddles two tiles. Provide the name of the folder containing the data files, and let globedem determine which files are required, read from the files, and concatenate the data into a single regular data grid.

```
latlim =[28.61 31.31]; lonlim = [-91.24 -88.62];
globedems(latlim,lonlim)

ans =
    'e10g'
    'f10g'

[Z,refvec] =
globedem('d:\externalData\globe\elev',1,latlim,lonlim);
size(Z)

ans =
        325.00        315.00
```

References

See Web site for the National Oceanic and Atmospheric Administration, National Geophysical Data Center

See Also

demdataui | dted | gtopo30 | satbath | tbase | usgsdem

Purpose

GLOBE data filenames for latitude-longitude quadrangle

Syntax

```
tileNames = globedems(latlim,lonlim)
tileNames = globedems(lat,lon)
```

Description

`tileNames = globedems(latlim,lonlim)` returns a cell array of the tile names covering the geographic region for GLOBEDEM digital elevation maps. The region is specified by two-element vectors of latitude and longitude limits in units of degrees.

`tileNames = globedems(lat,lon)` returns a cell array of the tile names covering the geographic region for GLOBEDEM digital elevation maps. The region is specified by scalar latitude and longitude points, in units of degrees.

Background

GLOBE, the Global Land One-km Base Elevation data, was compiled by the National Geophysical Data Center from more than 10 different sources of gridded elevation data. The data set consists of 16 tiles, each covering 50 by 90 degrees. Determining which tiles are needed to cover a particular region generally requires consulting an index map. This function takes the place of such a reference by returning the file names for a given geographic region.

Tips

The `globedems` function reads data from the format GLOBE Version 1.0. `globedem` first reads the corresponding ESRI header file found in the subdirectory `'/esri/hdr/'` and then the binary data file (with no extension).

Examples

Which tiles are needed for southern Louisiana?

```
latlim =[28.61 31.31];
lonlim = [-91.24 -88.62];
globedems(latlim,lonlim)

ans =
    'e10g'
    'f10g'
```

See Also `globedem`

Purpose

Read GPX file

Syntax

```
P = gpxread(filename)
P = gpxread(URL)
P = gpxread(...,Name,Value)
```

Description

`P = gpxread(filename)` reads point data from a GPS Exchange Format (GPX) file, `filename`, and returns an `n-by-1 geopoint` vector, `P` where `n` is the length of `P`.

`P = gpxread(URL)` reads the `GPX` data from a `URL`. The `URL` must include the protocol type (for example, `http://`).

The function searches first for `waypoint`, next for `route`, and then for `track` features. It returns the data of the first type found. The `Metadata` property of `P` contains any additional `track` or `route` metadata. For all feature types, the `Metadata` property contains a `FeatureType` field with a string value corresponding to the feature type (`'waypoint'`, `'track'`, or `'route'`) read from the file. If the file does not have feature type data, the function returns an empty `geopoint` vector.

If multiple feature types exist, the function displays only data from the first type returned. If the file contains `waypoints`, then `P` contains the `waypoints`. If the file contains only `routes`, then `P` contains the `route` points. If the file contains only `track` logs, then `P` contains the `track` points. If the file contains only `track` logs with multiple `track` segments, then the coordinates of the segments are concatenated together and contain `NaN` separators. `NaN` denotes numeric elements not found in the file. The empty string (`''`) is used to denote string elements not found in the file.

`P = gpxread(...,Name,Value)` reads point data from a GPX file with additional options, specified by one or more `name-value` pair arguments, that control various characteristics of the import. `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`) and is case insensitive. You can specify several name-value pair arguments in any order.

Tips

- Excluding extensions, GPX version 1.1 is fully supported. If any other version is detected, a warning is issued. However, in most cases, version 1.0 GPX files can be read successfully unless they contain certain metadata tags.
- The GPX file must conform to version 1.1: See GPX 1.1 Schema Documentation.

Input Arguments

filename

String that specifies the name of the GPX file to open. `filename` can include the directory path. Otherwise, the file must be in the current folder or in a folder on the MATLAB path. If the named file includes the extension `'.gpx'` (either uppercase or lowercase), you can omit the extension from `filename`.

URL

URL of file location. URL must include the protocol type.

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

FeatureType

String that specifies type of feature to read from file. `FeatureType` can be one of the following case-insensitive strings: `'track'`, `'route'`, `'waypoint'`, or `'auto'`. If the specified feature type is not found, then `P` is returned as an empty `geopoint` vector.

DataType: String.

Default: `'auto'`.

Index

Scalar, positive, integer-valued number that specifies `track` or `route` number to read from file. If the value of index is greater than the total number of tracks or routes, then `P` is returned as an empty `geopoint` vector. If the `Index` value is supplied, and the file contains only `waypoint` data, then the value is ignored.

Default: 1

Output Arguments

P

`geopoint` vector.

Definitions

waypoint

A point of interest, or named feature on a map.

track

An ordered list of waypoints that describe a path.

route

An ordered list of waypoints representing a series of turn points leading to a destination.

Examples

Read and Display Waypoints

Read and display waypoints from the `boston_placenames.gpx` file. Overlay the points onto the `bostion.tif` image.

Read the image and convert the length of the X and Y limits to meters for use with the projection structure, which uses meters.

```
p = gpxread('boston_placenames');
[A,R] = geotiffread('boston');
proj = geotiffinfo('boston');
mstruct = geotiff2mstruct(proj);
R.XLimWorld = R.XLimWorld * proj.UOMLengthInMeters;
R.YLimWorld = R.YLimWorld * proj.UOMLengthInMeters;
figure('Renderer', 'zbuffer');
```

```
axesm(mstruct)
mapshow(A,R);
```

Display the names and positions of each point.

```
for k=1:length(p)
   textm(p(k).Latitude, p(k).Longitude, p(k).Name, ...
      'Color',[0 0 0],'BackgroundColor',[0.9 0.9 0],...
      'Interpreter','none');
end
```

```
geoshow(p.Latitude, p.Longitude, 'DisplayType', 'point');
xlim(R.XLimWorld)
ylim(R.YLimWorld)
```

Working with Route Data

Read and display a route from Boston Logan International Airport to The MathWorks®, Inc. in Natick, MA.

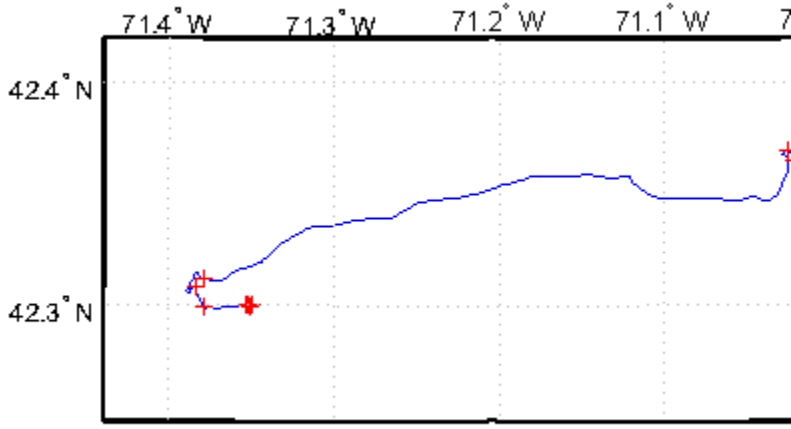
```
route = gpxread('sample_route');
```

Compute `latlim` and `lonlim`.

```
border = [-.05 .05];
latlim = [min(route.Latitude) max(route.Latitude)] + border;
lonlim = [min(route.Longitude) max(route.Longitude)] + border;
```

Display the route and the positions of each point containing turn-by-turn directions. Insert the turns into a legend.

```
directions = route(~cellfun(@isempty, route.Description));
turns = directions.Description;
figure('Renderer', 'zbuffer')
ax = usamap(latlim, lonlim)
setm(ax, 'MLabelParallel', 43.5)
geoshow(route.Latitude, route.Longitude)
for k=1:length(directions)
   textm(directions(k).Latitude, directions(k).Longitude,  ...
      turns{k}, 'Visible', 'off', 'FontSize',2);
end
pos = get(gcf, 'Position');
pos(1:2) = [300 300];
set(gcf, 'Position', pos .* [1 1 1.25 1.25]);
legend(handlem('text'), turns{:}, 'Location', 'SouthOutside')
geoshow(directions.Latitude, directions.Longitude,  ...
   'DisplayType', 'point');
```



Head southeast
Keep left at the fork, follow signs for I-90 W/I-93 S/Williams Tunnel/Mass Partial toll road
Take exit 13 to merge onto MA-30 E/Cochituate Rd toward Natick Partial toll road
Turn right onto Speen St
Merge onto MA-9 E/Worcester St via the ramp on the left to Boston
Slight right onto Apple Hill Dr
Turn left toward Apple Hill Dr
Take the 1st right onto Apple Hill Dr Destination will be on the right
The MathWorks, Inc., Natick, MA.

Working with Track Data

Read and display multiple track logs.

Read the track logs from `sample_tracks.gpx`.

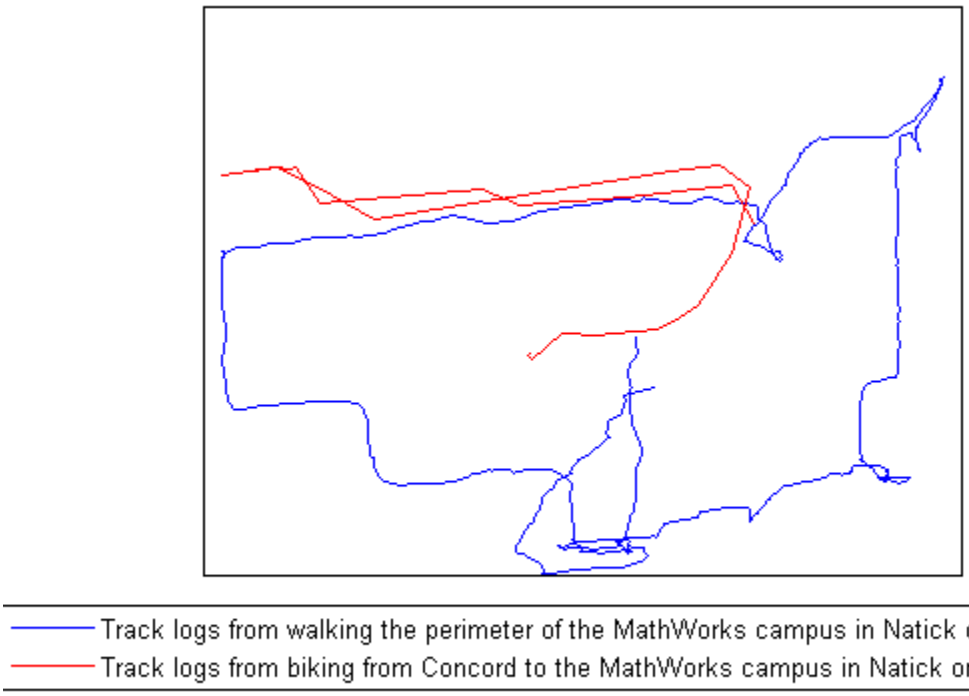
```
trk1 = gpxread('sample_tracks');
trk2 = gpxread('sample_tracks', 'Index', 2);
```

Display the track logs.

```
lat = [trk1.Latitude trk2.Latitude];
lon = [trk2.Longitude trk2.Longitude];
latlim = [min(lat) max(lat)];
lonlim = [min(lon) max(lon)];
figure; usamap(latlim, lonlim)
geoshow(trk1.Latitude, trk1.Longitude);
geoshow(trk2.Latitude, trk2.Longitude, 'Color', 'red');
```

Display the track logs near the MathWorks campus in Natick.

```
latlim = [min(trk1.Latitude) max(trk1.Latitude)];
lonlim = [min(trk1.Longitude) max(trk1.Longitude)];
figure;axesm('lambert',  ...
   'MapLatLimit', latlim, 'MapLonLimit', lonlim);
h1 = geoshow(trk1.Latitude, trk1.Longitude);
h2 = geoshow(trk2.Latitude, trk2.Longitude, 'Color', 'red');
legend([h1 h2], trk1.Metadata.Name, trk2.Metadata.Name, ...
   'Location', 'SouthOutside')
```



Working with Mixed Data

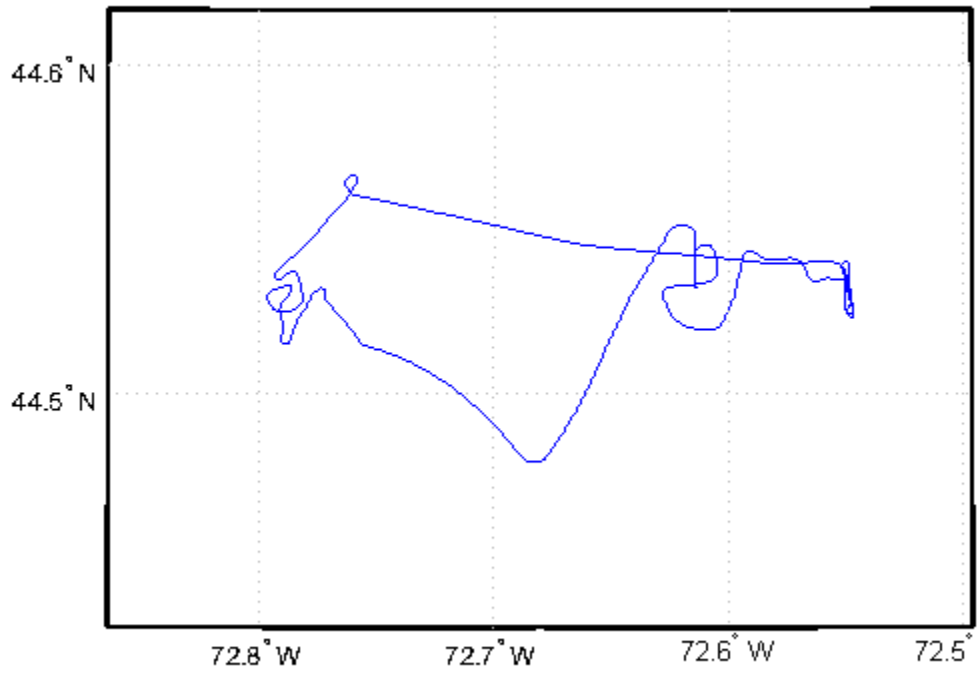
Read and display waypoints and a track log from the `sample_mixed.gpx` file.

```
wpt = gpxread('sample_mixed');
trk = gpxread('sample_mixed', 'FeatureType', 'track');
```

Display the waypoints and track log.

```
lat = [trk.Latitude  wpt.Latitude];
```

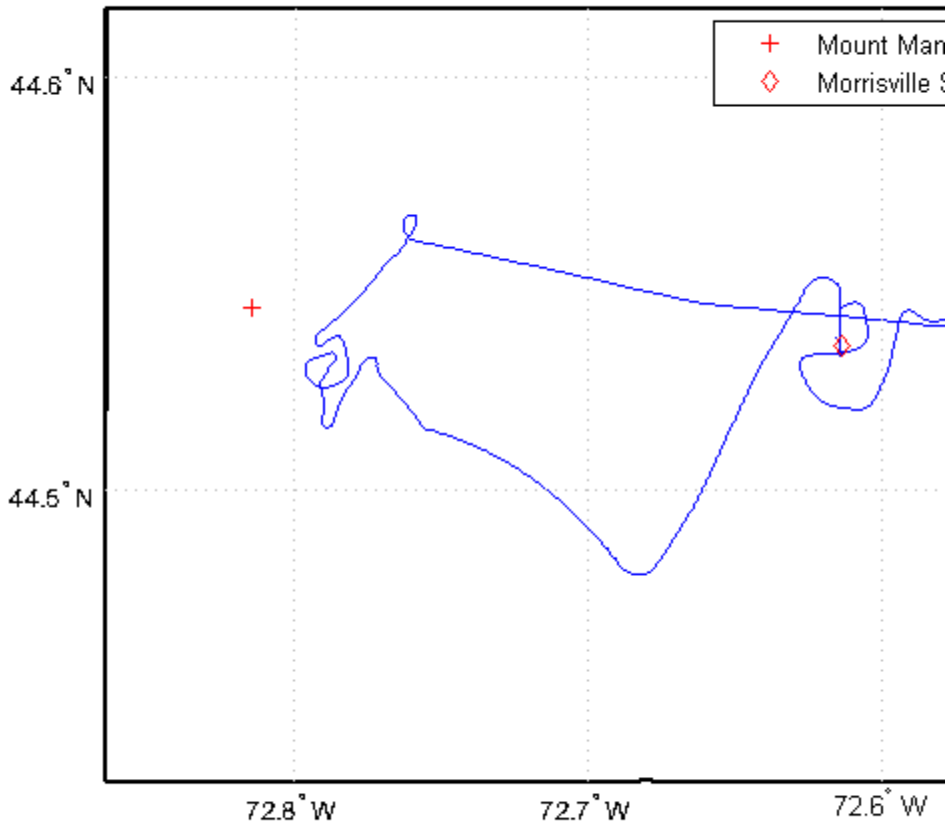
```
lon = [trk.Longitude wpt.Longitude];
border = [-.05 .05];
latlim = [min(lat) max(lat)] + border;
lonlim = [min(lon) max(lon)] + border;
figure; usamap(latlim, lonlim)
geoshow(trk.Latitude, trk.Longitude);
```



Display the names and positions of each point.

```
h1 = geoshow(wpt(1).Latitude, wpt(1).Longitude, ...
```

```
   'DisplayType', 'point');
h2 = geoshow(wpt(2).Latitude, wpt(2).Longitude,  ...
   'DisplayType', 'point', 'Marker', 'd');
names = wpt.Name;
legend([h1 h2], names{:});
pos = get(gcf, 'Position');
pos(1:2) = [300 300];
set(gcf, 'Position', pos .* [1 1 1.25 1.25]);
```



Elevation and Time Area Maps

Display elevation and time area maps and calculate cumulative ground distance using track logs.

Read the track log from the `sample_mixed.gpx` file.

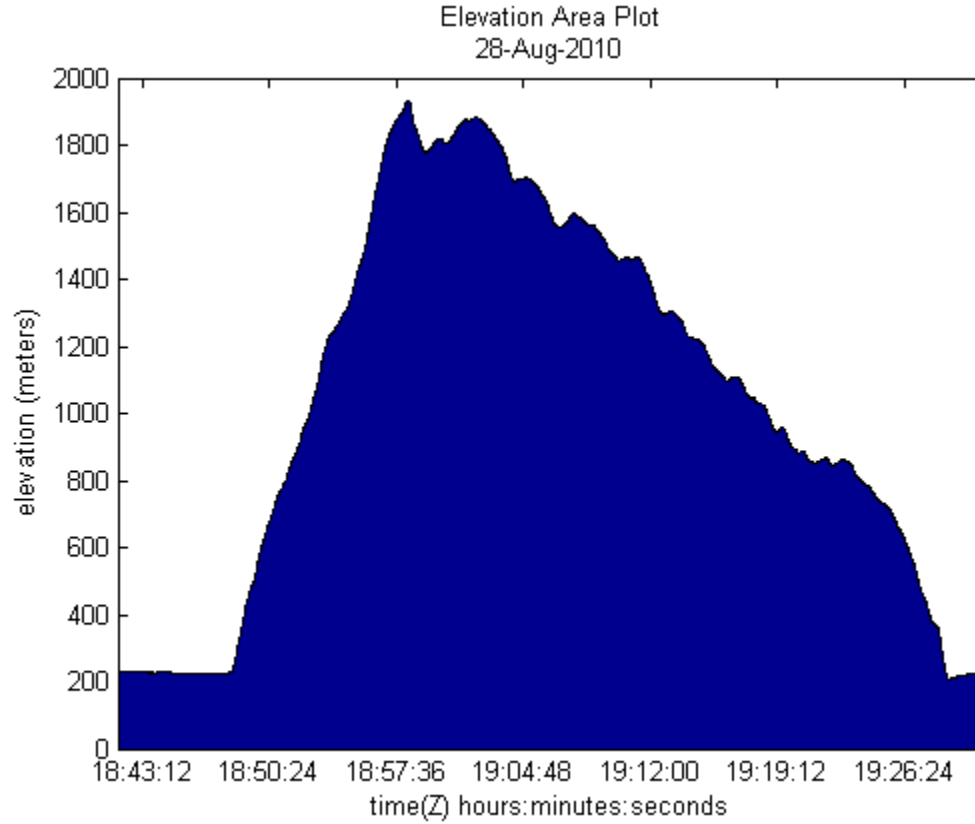
```
trk = gpxread('sample_mixed', 'FeatureType', 'track');
```

Time values are stored as strings in the GPX file. Use `datenum` to convert the strings to serial date numbers. Compute the time-of-day in hours-minutes-seconds.

```
timeStr = strrep(trk.Time, 'T', ' ');
timeStr = strrep(timeStr, '.000Z', '');
trk.DateNumber = datenum(timeStr, 31);
day = fix(trk.DateNumber(1));
trk.TimeOfDay = trk.DateNumber - day;
```

Display an area plot of the elevation and time values.

```
figure
area(trk.TimeOfDay, trk.Elevation)
datetick('x', 13, 'keepticks', 'keeplimits')
ylabel('elevation (meters)')
xlabel('time(Z) hours:minutes:seconds')
title({'Elevation Area Plot', datestr(day)});
```

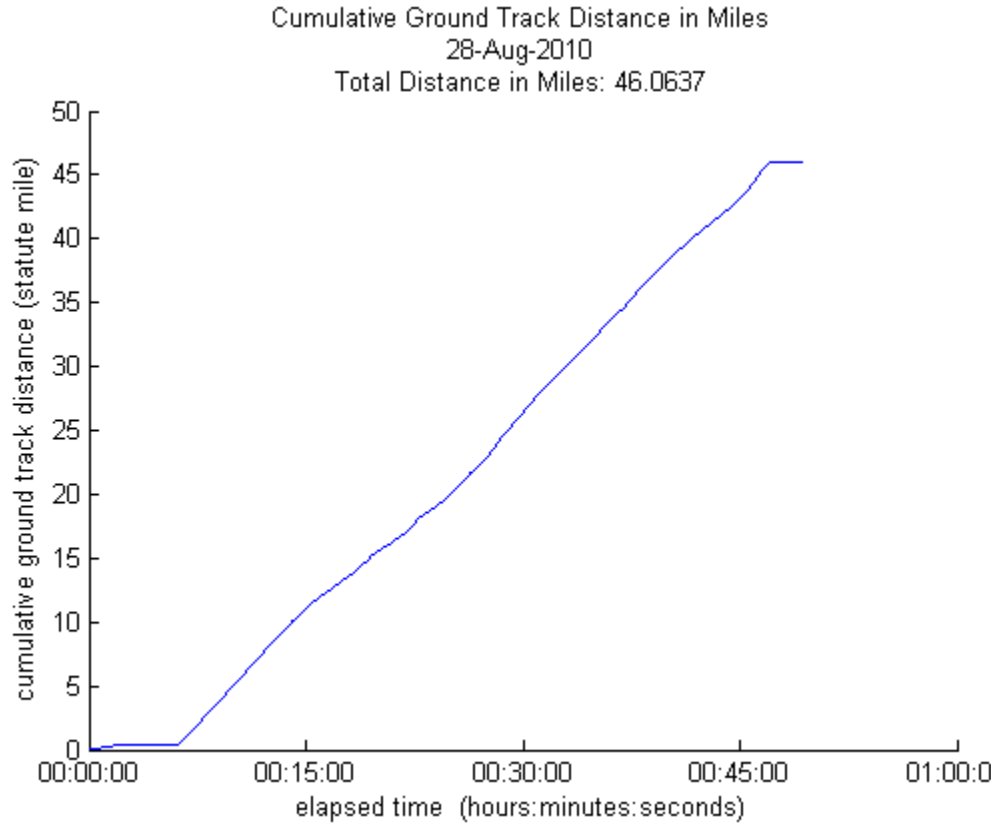


Calculate and display ground track distance. Convert distance in meters to distance in U.S. survey miles.

```
e = wgs84Ellipsoid;
lat = trk.Latitude;
lon = trk.Longitude;
d = distance(lat(1:end-1), lon(1:end-1), lat(2:end), lon(2:end), e);
d = d * unitsratio('sm', 'meter');
```

Display the cumulative ground track distance and elapsed time.

```
trk.ElapsedTime = trk.TimeOfDay - trk.TimeOfDay(1);
figure
line(trk.ElapsedTime(2:end), cumsum(d))
datetick('x', 13)
ylabel('cumulative ground track distance (statute mile)')
xlabel('elapsed time  (hours:minutes:seconds)')
title({'Cumulative Ground Track Distance in Miles', datestr(day),  ...
   ['Total Distance in Miles: ' num2str(sum(d))]});
```



See Also

`geopoint` | `shaperead`

gradientm

Purpose

Calculate gradient, slope and aspect of data grid

Syntax

```
[ASPECT, SLOPE, gradN, gradE] = gradientm(Z, R)
[...] = gradientm(lat, lon, Z)
[...] = gradientm(..., ellipsoid)
[...] = gradientm(lat, lon, Z, ellipsoid, units)
```

Description

`[ASPECT, SLOPE, gradN, gradE] = gradientm(Z, R)` computes the slope, aspect and north and east components of the gradient for a regular data grid `Z` with three-element referencing vector `refvec`. If the grid contains elevations in meters, the resulting aspect and slope are in units of degrees clockwise from north and up from the horizontal. The north and east gradient components are the change in the map variable per meter of distance in the north and east directions. The computation uses finite differences for the map variable on the default earth ellipsoid.

`R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to or from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Nearest-neighbor interpolation is used by default. NaN is returned for points outside the grid limits or for which `lat` or `lon` contain NaN. All angles are in units of degrees.

`[...] = gradientm(lat, lon, Z)` does the computation for a geolocated data grid. `lat` and `lon`, the latitudes and longitudes of the geolocation points, are in degrees.

`[...] = gradientm(..., ellipsoid)` uses the reference ellipsoid specified by the input `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. If the map contains elevations in the same units of length as the semimajor axis of the ellipsoid, the slope and aspect are in units of degrees. This calling form is most useful for computations on bodies other than the earth.

`[...] = gradientm(lat, lon, Z, ellipsoid, units)` specifies the angle units of the latitude and longitude inputs. If omitted, `'degrees'` are assumed. For elevation maps in the same units as `ellipsoid(1)`, the resulting slope and aspect are in the specified units. The components of the gradient are the change in the map variable per unit of length, using the same length unit as the semimajor axis of the ellipsoid.

Tips

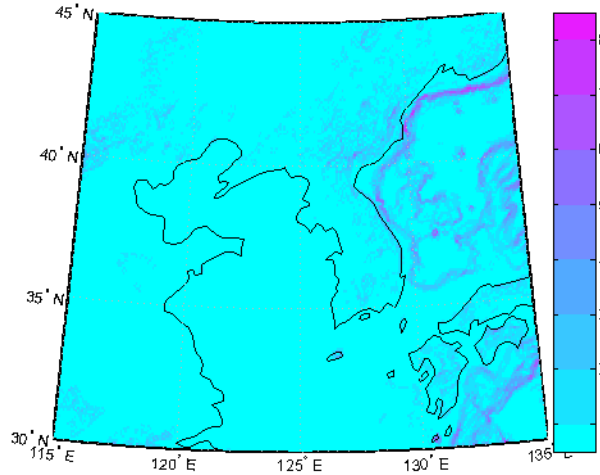
Coarse digital elevation models can considerably underestimate the local slope. For the preceding map, the elevation points are separated by about 10 kilometers. The terrain between two adjacent points is modeled as a linear variation, while actual terrain can vary much more abruptly over such a distance.

Examples

Compute and display the slope for the 30 arc-second (10 km) Korea elevation data. Slopes in the Sea of Japan are up to 8 degrees at this grid resolution.

```
load korea
[aspect, slope, gradN, gradE] = gradientm(map, refvec);
worldmap(slope, refvec)
geoshow(slope, refvec, 'DisplayType', 'texturemap')
cmap = cool(10);
demcmap('inc', slope, 1, [], cmap)
colorbar
latlim = getm(gca,'maplatlimit');
lonlim = getm(gca,'maplonlimit');
```

```
land = shaperead('landareas',...
  'UseGeoCoords', true, 'BoundingBox', [lonlim' latlim']);
geoshow(land, 'FaceColor', 'none')
set(gca, 'Visible', 'off')
```



See Also

`viewshed`

How To

- "Geolocated Data Grids"

Purpose

Identify matching fields in fixed record length files

Syntax

```
grepfields(filename,searchstring)
grepfields(filename,searchstring,casesens)
grepfields(filename,searchstring,casesens,startcol)
grepfields(filename,searchstring,casesens,startfield,fields)
grepfields(filename,searchstring,casesens,startfield,fields,
   machineformat)
indx = grepfields(...)
```

Description

`grepfields(filename,searchstring)` displays lines in the file that begin with the search string. The file must have fixed-length records with line endings.

`grepfields(filename,searchstring,casesens)`, with `casesens` `'matchcase'`, specifies a case-sensitive search. If omitted or `'none'`, the search string matches regardless of the case.

`grepfields(filename,searchstring,casesens,startcol)` searches starting with the specified column. `startcol` is an integer between 1 and the bytes per record in the file. In this calling form, the file is regarded as a text file with line endings.

`grepfields(filename,searchstring,casesens,startfield,fields)` searches within the specified field. `startfield` is an integer between 1 and the number of fields per record. The format of the file is described by the `fields` structure. See `readfields` for recognized fields structure entries. In this calling form, the file can be binary and lack line endings. The search is within `startfield`, which must be a character field.

`grepfields(filename,searchstring,casesens,startfield,fields,` `machineformat)` opens the file with the specified machine format. `machineformat` must be recognized by `fopen`.

`indx = grepfields(...)` returns the record numbers of matched records instead of displaying them on screen.

Examples

Write a binary file and read it:

```
fid = fopen('testbin','wb');
for i = 1:3
 fwrite(fid,['character' num2str(i) ],'char');
 fwrite(fid,i,'int8');
 fwrite(fid,[i i],'int16');
 fwrite(fid,i,'integer*4');
 fwrite(fid,i,'real*8');
end
fclose(fid);

fs(1).length = 10;fs(1).type = 'char';fs(1).name = 'field 1';
fs(2).length = 1;fs(2).type = 'int8';fs(2).name = 'field 2';
fs(3).length = 2;fs(3).type = 'int16';fs(3).name = 'field 3';
fs(4).length = 1;fs(4).type = 'integer*4';fs(4).name = 'field 4';
fs(5).length = 1;fs(5).type = 'float64';fs(5).name = 'field 5';
```

Find the record matching the string `'character2'`. The record contains binary data, which cannot be properly displayed.

```
grepfields('testbin','character2','none',1,fs)
character2? ? ?   ?@

indx = grepfields('testbin','character2','none',1,fs)
indx =
     2
```

Read the formatted file containing the following:

```
-------------------------------------------------------
character data 1  1  2  3 1e6 10D6

character data 2 11 22 33 2e6 20D6

character data 3111222333 3e6 30D6
-------------------------------------------------------
```

```
fs(1).length = 16;fs(1).type = 'char';fs(1).name = 'field 1';
fs(2).length = 3;fs(2).type = '%3d';fs(2).name = 'field 2';
fs(3).length = 1;fs(3).type = '%4g';fs(3).name = 'field 3';
fs(4).length = 1;fs(4).type = '%5D'; fs(4).name = 'field 4';
fs(5).length = 1;fs(5).type = 'char';fs(5).name = '';
```

Find the records that match at the beginning of the line.

```
grepfields('testfile1','character')
character data 1  1  2  3 1e6 10D6
character data 2 11 22 33 2e6 20D6
character data 3111222333 3e6 30D6

grepfields('testfile1','character data 2')
character data 2 11 22 33 2e6 20D6
```

Find the records that match, starting the search in column 11.

```
grepfields('testfile1','data 2','none',11)
character data 2 11 22 33 2e6 20D6
```

Search record number 1.

```
grepfields('testfile1','character data 2','none',1,fs)
character data 2 11 22 33 2e6 20D6
```

Limitations

Searches are limited to fields containing character data.

Tips

See `readfields` for a complete discussion of the format and contents of the `fields` argument.

See Also

`readfields` | `fopen`

gridm

Purpose

Toggle and control display of graticule lines

Syntax

```
gridm
gridm('on')
gridm('off')
gridm('reset')
gridm(linespec)
gridm(MapAxesPropertyName, PropertyValue,...)
h = gridm(...)
```

Description

`gridm` toggles the display of a latitude-longitude graticule. The choice of meridians and parallels, as well as their graphics properties, depends on the property settings of the map axes.

`gridm('on')` creates the graticule, if it does not yet exist, and makes it visible.

`gridm('off')` makes the graticule invisible.

`gridm('reset')` redraws the graticule using the current map axes properties.

`gridm(linespec)` uses any valid *`linespec`* string to control the graphics properties of the lines in the graticule.

`gridm(MapAxesPropertyName, PropertyValue,...)` sets the appropriate graticule properties to the desired values. For a description of these property names and values, see the "Properties That Control the Grid" on page 3-59 section of the `axesm` reference page.

`h = gridm(...)` returns the handles of the graticule lines. If both parallels and meridians exist, then `h` is a two-element vector: `h(1)` is the handle to the line comprising the parallels, and `h(2)` is the handle to the line comprising the meridians.

Tips

- You can also create or alter map grid properties using the `axesm` or `setm` functions.
- By default the Clipping property is set to `'off'`. Override this setting with the following code:

```
hgrat = gridm('on');
set(hgrat,'Clipping','on')
```

See Also

axesm | setm

grid2image

Purpose

Display regular data grid as image

Syntax

```
grid2image(Z,R)
grid2image(Z,R,'PropertyName',PropertyValue,...)
h = grid2image(...)
```

Description

`grid2image(Z,R)` displays a regular data grid `Z` as an image. The image is displayed in unprojected form, with longitude as *x* and latitude as *y*, producing considerable distortion away from the Equator. `Z` can be *M*-by-*N* or *M*-by-*N*-by-3, and can contain `double`, `uint8`, or `uint16` data. The grid is georeferenced to latitude-longitude by `R`, which can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)` and its `RasterInterpretation` must be `'cells'`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel.

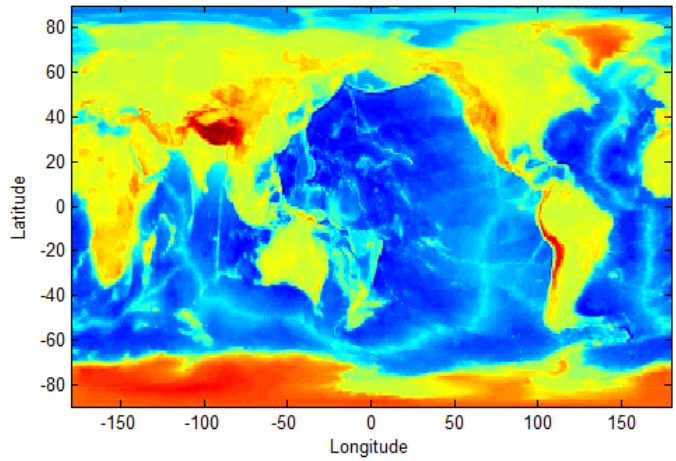
`grid2image(Z,R,'PropertyName',PropertyValue,...)` uses the specified image properties to display the map. See the `image` function reference page for a list of properties that can be changed.

`h = grid2image(...)` returns the handle of the image object displayed.

Examples

Display a regular data grid as an image.

```
load topo
R = georasterref('RasterSize', size(topo), ...
   'Latlim', [-90 90], 'Lonlim', [0 360]);
figure; grid2image(topo, R)
```



See Also

`image` | `mapshow` | `mapview` | `meshm` | `surfacem` | `surfm`

grn2eqa

Purpose

Convert from Greenwich to equal area coordinates

Syntax

```
[x,y] = grn2eqa(lat,lon)
[x,y] = grn2eqa(lat,lon,origin)
[x,y] = grn2eqa(lat,lon,origin,ellipsoid)
[x,y] = grn2eqa(lat,lon,origin,units)
mat = grn2eqa(lat,lon,origin...)
```

Description

`[x,y] = grn2eqa(lat,lon)` converts the Greenwich coordinates `lat` and `lon` to the equal-area coordinate points `x` and `y`.

`[x,y] = grn2eqa(lat,lon,origin)` specifies the location in the Greenwich system of the *x-y* origin (0,0). The two-element vector `origin` must be of the form `[latitude, longitude]`. The default places the origin at the Greenwich coordinates (0^o,0^o).

`[x,y] = grn2eqa(lat,lon,origin,ellipsoid)` specifies the ellipsoidal model of the figure of the Earth using `ellipsoid`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The `ellipsoid` is spherical by default.

`[x,y] = grn2eqa(lat,lon,origin,units)` specifies the units for the inputs, where *`units`* is any valid angle units string. The default value is `'degrees'`.

`mat = grn2eqa(lat,lon,origin...)` packs the outputs into a single variable.

The `grn2eqa` function converts data from Greenwich-based latitude-longitude coordinates to equal-area *x-y* coordinates. The opposite conversion can be performed with `eqa2grn`.

Examples

```
lats = [56 34]; longs = [-140 23];
[x,y] = grn2eqa(lats,longs)

x =
   -2.4435    0.4014
y =
```

```
    0.8290    0.5592
```

See Also

eqa2grn | hista

gshhs

Purpose

Read Global Self-Consistent Hierarchical High-Resolution Shoreline

Syntax

```
S = gshhs(filename)
S = gshhs(filename, latlim, lonlim)
indexfilename = gshhs(filename, 'createindex')
```

Description

`S = gshhs(filename)` reads GSHHS vector data for the entire world from `filename`. GSHHS files must have names of the form `gshhs_x.b`, `wdb_borders_x.b`, or `wdb_rivers_x.b`, where *x* is one of the letters `c`, `l`, `i`, `h` or `f`, corresponding to increasing resolution (and file size). The result returned in `S` is a polygon or line geographic data structure array (a *geostruct*, with `'Lat'` and `'Lon'` coordinate fields).

`S = gshhs(filename, latlim, lonlim)` reads a subset of the vector data from `filename`. The limits of the desired data are specified as two-element vectors of latitude, `latlim`, and longitude, `lonlim`, in degrees. The elements of `latlim` and `lonlim` must be in ascending order. Longitude limits range from `[-180 195]`. If `latlim` is empty the latitude limits are `[-90 90]`. If `lonlim` is empty, the longitude limits are `[-180 195]`.

`indexfilename = gshhs(filename, 'createindex')` creates an index file for faster data access when requesting a subset of a larger dataset. The index file has the same name as the GSHHS data file, but with the extension `'i'`, instead of `'b'` and is written in the same folder as `filename`. The name of the index file is returned, but no coastline data are read. A call using this option should be followed by an additional call to `gshhs` to import actual data. On that and subsequent calls, `gshhs` detects the presence of the index file and uses it to access records by location much faster than it would without an index.

Output Structure

The output structure `S` contains the following fields. All latitude and longitude values are in degrees.

Field Name	Field Contents
`'Geometry'`	`'Line'` or `'Polygon'`
`'BoundingBox'`	`[minLon minLat; maxLon maxLat]`
`'Lon'`	Coordinate vector
`'Lat'`	Coordinate vector
`'South'`	Southern latitude boundary
`'North'`	Northern latitude boundary
`'West'`	Western longitude boundary
`'East'`	Eastern longitude boundary
`'Area'`	Area of polygon in square kilometers
`'Level'`	Scalar value ranging from 1 to 4, indicates level in topological hierarchy
`'LevelString'`	`'land'`, `'lake'`, `'island_in_lake'`, `'pond_in_island_in_lake'`, or `''`
`'NumPoints'`	Number of points in the polygon
`'FormatVersion'`	Format version of data file. Positive integer for versions 3 and later; empty for versions 1 and 2.
`'Source'`	Source of data: `'WDBII'` or `'WVS'`
`'CrossesGreenwich'`	Scalar flag: `true` if the polygon crosses the prime meridian; `false` otherwise
`'GSHHS_ID'`	Unique polygon scalar id number, starting at 0

For releases 2.0 and higher (`FormatVersion` 7 and higher), the following additional fields are included in the output structure:

Field Name	Field Contents
`'RiverLake'`	Scalar flag: `true` if the polygon is the fat part of a major river and the `Level` value is set to 2; `false` otherwise.
`'AreaFull'`	Area of original full-resolution polygon in units $\frac{1}{10} km^2$.
`'Container'`	ID of container polygon that encloses this polygon. Set to -1 to indicate none.
`'Ancestor'`	ID of ancestor polygon in the full resolution set that was the source of this polygon. Set to -1 to indicate none.

For Release 2.2 and higher (`FormatVersion` 9 and higher) the following additional field is included in the output structure:

Field Name	Field Contents
`'CrossesDateline'`	Scalar flag: `true` if the polygon crosses the dateline; `false` otherwise.

Tips

- If you are extracting data within specified geographic limits and using data other than coarse resolution, consider creating an index file first. Also, to speed rendering when mapping very large amounts of data, you might want to plot the data as `NaN`-clipped lines rather than as patches.
- When you specify latitude-longitude limits, polygons that completely fall outside those limits are excluded, but no trimming of features that partially traverse the region is performed. If you want to eliminate data outside of a rectangular region of interest, you can use `maptrimp` with the `Lat` and `Lon` fields of the geostruct returned by `gshhs` to clip the data to your region and still maintain polygon topology.

- You can read the WDB rivers and borders datasets but the `LevelString` field will be empty. The `Level` values vary from feature to feature but the interpretations of these values are not documented as part of the GSHHS distribution and are therefore not converted to strings.
- The following examples use publicly available GSHHS data files that do not ship with the Mapping Toolbox software. For details on locating GSHHS data for download over the Internet, see the following documentation at the MathWorks Web site: http://www.mathworks.com/help/map/finding-geospatial-data.html .

Background

The Global Self-Consistent Hierarchical High-Resolution Shoreline was created by Paul Wessel of the University of Hawaii and Walter H.F. Smith of the NOAA Geosciences Lab. At the full resolution the data requires 85 MB uncompressed, but lower resolution versions are also provided. This database includes coastlines, major rivers, and lakes. The GSHHS data in various resolutions is available over the Internet from the National Oceanic and Atmospheric Administration, National Geophysical Data Center Web site.

Version 3 (Release 1.3) of the `gshhs_c.b` (coarse) data set ships with the toolbox in the `toolbox/map/mapdata` folder. For details, type

```
type gshhs_c.txt
```

at the MATLAB command prompt. The `gshhs` function has been qualified on GSHHS releases 1.1 through 2.1 (version 8). It should also be able to read newer versions, if they adhere to the same header format as releases 2.0 and 2.1.

Examples

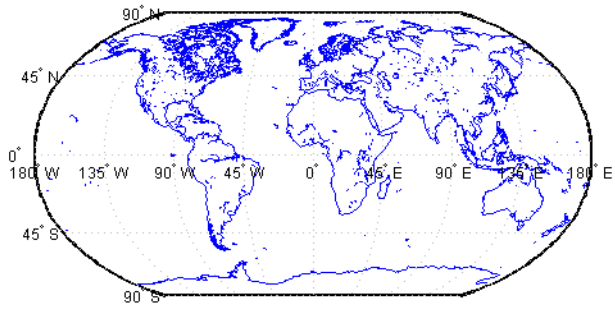
Example 1

Read the entire coarse data set (located on the MATLAB path in *`matlabroot`*`/toolbox/map/mapdata`):

```
filename = gunzip('gshhs_c.b.gz', tempdir);
world = gshhs(filename{1});
```

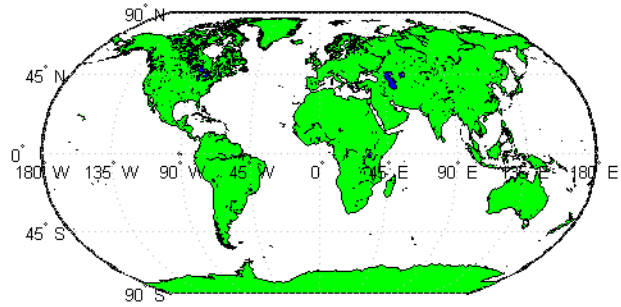
Display as a coastline:

```
figure
worldmap world
geoshow([world.Lat], [world.Lon])
```



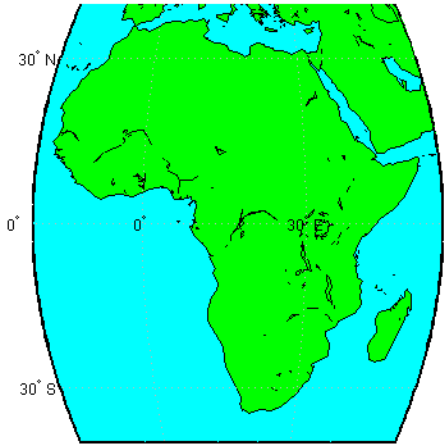
Display each level in a different color.

```
levels = [world.Level];
land = (levels == 1);
lake = (levels == 2);
island = (levels == 3);
figure
worldmap world
geoshow(world(land),  'FaceColor', [0 1 0])
geoshow(world(lake),  'FaceColor', [0 0 1])
geoshow(world(island),'FaceColor', [1 1 0])
```



After creating an index file, read and display Africa as a green polygon; note that `gshhs` detects and uses the index file automatically:

```
indexname = gshhs(filename{1}, 'createindex');
figure
worldmap Africa
projection = gcm;
latlim = projection.maplatlimit;
lonlim = projection.maplonlimit;
africa = gshhs(filename{1}, latlim, lonlim);
geoshow(africa, 'FaceColor', 'green')
setm(gca, 'FFaceColor', 'cyan')
```



Delete the temporary files:

```
delete(filename{1})
delete(indexname)
```

Example 2

Read the intermediate resolution database for South America:

```
s = gshhs('gshhs_i.b',[-60 -15],[-90 -30])
```

Example 3

Read the full-resolution file for East and West Falkland Islands (Islas Malvinas):

```
s = gshhs('gshhs_f.b',[-55 -50],[-65 -55])
```

Example 4

Create the index file for the high-resolution database:

```
gshhs('gshhs_h.b','createindex')
```

See Also

dcwdata | geoshow | maptrimp | shaperead | vmap0data | worldmap

gtextm

Purpose

Place text on map using mouse

Syntax

```
h = gtextm(string)
h = gtextm(string,PropertyName,PropertyValue,...)
```

Description

`h = gtextm(string)` places the text object string at the position selected by mouse input. When this function is called, the current map axes are brought up and the cursor is activated for mouse-click position entry. The text object's handle is returned.

`h = gtextm(string,PropertyName,PropertyValue,...)` allows the specification of any properties supported by the MATLAB `text` function.

Examples

Create map axes:

```
axesm('sinusoid','FEdgeColor','red')
gtextm('hello world','FontWeight','bold')
```

Click inside the frame and the text appears.

See Also

`axesm` | `textm`

Purpose

Read 30-arc-second global digital elevation data (GTOPO30)

Syntax

```
[Z,refvec] = gtopo30(tilename)
[Z,refvec] = gtopo30(tilename,samplefactor)
[Z,refvec] = gtopo30(tilename,samplefactor,latlim,lonlim)
[Z,refvec] = gtopo30(foldername, ...)
```

Description

`[Z,refvec] = gtopo30(tilename)` reads the GTOPO30 tile specified by `tilename` and returns the result as a regular data grid. `tilename` is a string which does not include an extension and indicates a GTOPO30 tile in the current folder or on the MATLAB path. If `tilename` is empty or omitted, a file browser will open for interactive selection of the GTOPO30 header file. The data is returned at full resolution with the latitude and longitude limits determined from the GTOPO30 tile. The data grid, `Z`, is returned as an array of elevations. Elevations are given in meters above mean sea level using WGS84 as a horizontal datum. `refvec` is the associated referencing vector.

`[Z,refvec] = gtopo30(tilename,samplefactor)` reads a subset of the elevation data from `tilename`. `samplefactor` is a scalar integer, which when equal to 1 reads the data at its full resolution. When `samplefactor` is an integer n greater than one, every nth point is read. If `samplefactor` is omitted or empty, it defaults to 1.

`[Z,refvec] = gtopo30(tilename,samplefactor,latlim,lonlim)` reads a subset of the elevation data from `tilename` using the latitude and longitude limits `latlim` and `lonlim` specified in degrees. `latlim` is a two-element vector of the form:

```
[southern_limit northern_limit]
```

Likewise, `lonlim` has the form:

```
[western_limit eastern_limit]
```

If `latlim` and `lonlim` are omitted, the coordinate limits are determined from the file. The latitude and longitude limits are snapped outward to define the smallest possible rectangular grid of GTOPO30 cells that

fully encloses the area defined by the input limits. Any cells in this grid that fall outside the extent of the tile are filled with NaN.

`[Z,refvec] = gtopo30(foldername, ...)` is similar to the syntaxes above except that GTOPO30 data are read and concatenated from multiple tiles within a GTOPO30 CD-ROM or folder structure. The `foldername` input is a string with the name of the folder which contains the GTOPO30 tile folders or GTOPO30 tiles. Within the tile folders are the uncompressed data files. The `foldername` for CD-ROMs distributed by the USGS is the device name of the CD-ROM drive. As with the case with a single tile, any cells in the grid specified by `latlim` and `lonlim` are NaN filled if they are not covered by a tile within `foldername`. `samplefactor` if omitted or empty defaults to 1. `latlim` if omitted or empty defaults to `[-90 90]`. `lonlim` if omitted or empty defaults to `[-180 180]`.

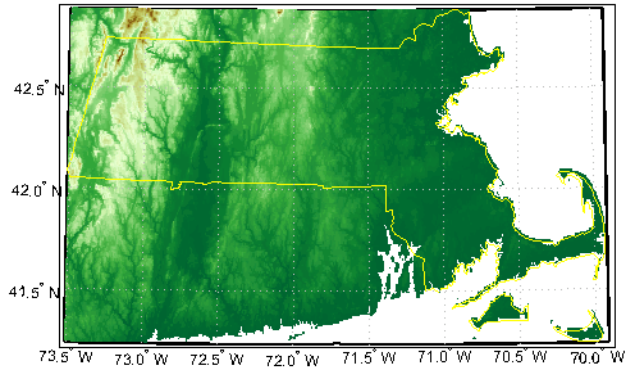
For details on locating GTOPO30 data for download over the Internet, see http://www.mathworks.com/help/map/finding-geospatial-data.html .

Examples

Example 1

Extract and display full resolution data for the state of Massachusetts:

```
% Read the stateline polygon boundary and calculate boundary limits.
Massachusetts = shaperead('usastatehi','UseGeoCoords',true, ...
  'Selector',{@(name) strcmpi(name,'Massachusetts'),'Name'});
latlim = [min(Massachusetts.Lat(:)) max(Massachusetts.Lat(:))];
lonlim = [min(Massachusetts.Lon(:)) max(Massachusetts.Lon(:))];

% Read the GTOPO30 data at full resolution.
[Z,refvec] = gtopo30('W100N90',1,latlim,lonlim);

% Display the data grid and overlay the stateline boundary.
figure
usamap(Z,refvec);
geoshow(Z,refvec,'DisplayType','surface')
demcmap(Z)
geoshow(Massachusetts,'DisplayType','polygon',...
  'facecolor','none','edgecolor','y')
```

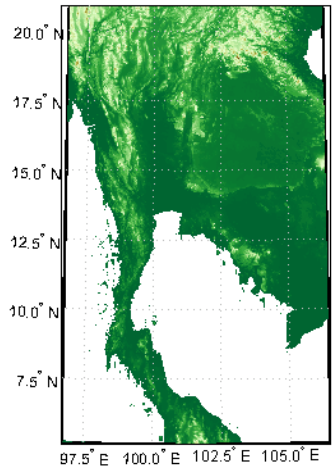


Example 2

```
% Extract every 20th point from a tile.
% Provide an empty filename and select the file interactively.
[Z,refvec] = gtopo30([],20);
```

Example 3

```
% Extract data for Thailand, an area which straddles two tiles.
% The data is on CD number 3 distributed by the USGS.
% The CD-device is 'F:\'
latlim = [5.22 20.90];
lonlim = [96.72 106.38];
gtopo30s(latlim,lonlim)
% Extract every fifth data point for Thailand.
% Specify actual folder or mapped drive if not "F:\'
[Z,refvec] = gtopo30('F:\',5,latlim,lonlim);
worldmap(Z,refvec);
geoshow(Z,refvec,'DisplayType','surface')
demcmap(Z)
```



Example 4

```
% Extract every 10th point from a column of data 5 degrees around
% the prime meridian. The current folder contains GTOPO30 data.
[Z,refvec] = gtopo30(pwd,10,[],[-5 5]);
```

See Also

gtopo30s | globedem | dted | satbath | tbase | usgsdem

Purpose

GTOPO30 data filenames for latitude-longitude quadrangle

Syntax

```
tileNames = gtopo30s(latlim,lonlim)
tileNames = gtopo30s(lat,lon)
```

Description

`tileNames = gtopo30s(latlim,lonlim)` returns a cell array of the tile names covering the geographic region for GTOPO30 digital elevation maps (also referred to as "30-arc second" DEMs). `latlim` and `lonlim` specify the region as two-element vectors of latitude and longitude limits in units of degrees.

`tileNames = gtopo30s(lat,lon)` returns a cell array of the tile names covering the geographic region for GTOPO30 digital elevation maps. `lat` and `lon` specify the region as scalar latitude and longitude points.

See Also

`gtopo30`

handlem

Purpose

Handles of displayed map objects

Syntax

```
handlem or handlem('taglist')
handlem('prompt')
h = handlem(object)
h = handlem(tagstr)
h = handlem('object',axesh) or handlem(tagstr,axesh)
h = handlem(...,axesh,'searchmethod')
h = handlem(handles)
```

Description

`handlem or handlem('taglist')` displays a dialog box for selecting objects that have their `Tag` property set.

`handlem('prompt')` displays a dialog box for selecting objects based on the object strings listed below.

`h = handlem(object)` returns the handles of those objects in the current axes specified by the input string, *`object`*. The options for the *`object`* string are defined by the following list:

`'all'`	All children
`'clabel'`	Contour labels
`'contour'`	hggroups containing contours
`'fillcontour'`	hggroups containing filled contours
`'frame'`	Map frame
`'grid'`	Map grid lines
`'hggroup'`	All hggroup objects
`'hidden'`	Hidden objects
`'image'`	Untagged image objects
`'light'`	Untagged light objects
`'line'`	Untagged line objects

`'map'`	All objects on the map, excluding the frame and grid
`'meridian'`	Longitude grid lines
`'mlabel'`	Longitude labels
`'parallel'`	Latitude grid lines
`'plabel'`	Latitude labels
`'patch'`	Untagged patch objects
`'scaleruler'`	Scaleruler objects
`'surface'`	Untagged surface objects
`''text''`	Untagged text objects
`'tissot'`	Tissot indicatrices
`'visible'`	Visible objects

`h = handlem(`*`tagstr`*`)` returns the handles for any objects whose tags match the string `tagstr`.

`h = handlem('`*`object`*`',axesh) or handlem(`*`tagstr`*`,axesh)` searches within the axes specified by the input handle `axesh`.

`h = handlem(...,axesh,'`*`searchmethod`*`')` controls the method used to match the `object` input. If omitted, `'exact'` is assumed. Search method `'strmatch'` searches for matches that start at the beginning of the tag. Search method `'findstr'` searches anywhere within the tag for the object string.

`h = handlem(handles)` returns those elements of an input vector of handles that are still valid.

A prefix of `'all'` may be applied to strings defining a Handle Graphics® object type (text, line, patch, light, surface, or image) to find all object handles that meet the type criteria (for example, `'allimage'`). Without the `'all'` prefix, only handles with an empty tag are returned.

See Also

`findobj`

hidem

Purpose

Hide specified graphic objects on map axes

Syntax

```
hidem
hidem(handle)
hidem(object)
```

Description

`hidem` brings up a dialog box for selecting the objects to hide (set their `Visible` property to `'off'`).

`hidem(handle)` hides the objects specified by a vector of handles.

`hidem(object)` hides those objects specified by the *`object`* string, which can be any string recognized by the `handlem` function.

See Also

`clma` | `clmo` | `handlem` | `namem` | `showm` | `tagm`

Purpose

Histogram for geographic points with equal-area bins

Syntax

```
[lat,lon,num] = hista(lats,lons)
[lat,lon,num] = hista(lats,lons,binarea)
[lat,lon,num] = hista(lats,lons,binarea,ellipsoid)
[lat,lon,num] = hista(lats,lons,binarea,units)
```

Description

`[lat,lon,num] = hista(lats,lons)` returns the center coordinates of equal-area bins and the number of observations falling in each based on the geographically distributed input data.

`[lat,lon,num] = hista(lats,lons,binarea)` specifies the equal-area bin size, in square kilometers. It is 100 km^2 by default.

`[lat,lon,num] = hista(lats,lons,binarea,ellipsoid)` specifies the shape of the Earth using `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The default ellipsoid model is a unit sphere.

`[lat,lon,num] = hista(lats,lons,binarea,units)` specifies the standard angle unit string. The default value is `'degrees'`.

Examples

Create random data:

```
lats = rand(4)

lats =
    0.4451    0.8462    0.8381    0.8318
    0.9318    0.5252    0.0196    0.5028
    0.4660    0.2026    0.6813    0.7095
    0.4186    0.6721    0.3795    0.4289

longs = rand(4)

longs =
    0.3046    0.3028    0.3784    0.4966
    0.1897    0.5417    0.8600    0.8998
```

```
    0.1934    0.1509    0.8537    0.8216
    0.6822    0.6979    0.5936    0.6449
```

Bin the data in 50-by-50 km cells (2500 sq km):

```
[lat,lon,num] = hista(lats,longs,2500);
[lat lon num]

ans =
    0.2574    0.3757    4.0000
    0.7070    0.3757    5.0000
   -0.1923    0.8253    1.0000
    0.2573    0.8253    2.0000
    0.7070    0.8254    4.0000
```

See Also

eqa2grn | grn2eqa | histr

Purpose

Histogram for geographic points with equirectangular bins

Syntax

```
[lat,lon,num,wnum] = histr(lats,lons)
[lat,lon,num,wnum] = histr(lats,lons,units)
[lat,lon,num,wnum] = histr(lats,lons,bindensty)
```

Description

`[lat,lon,num,wnum] = histr(lats,lons)` returns the center coordinates of equal-rectangular bins and the number of observations, `num`, falling in each based on the geographically distributed input data. Additionally, an area-weighted observation value, `wnum`, is returned. `wnum` is the bin's `num` divided by its normalized area. The largest bin has the same `num` and `wnum`; a smaller bin has a larger `wnum` than `num`.

`[lat,lon,num,wnum] = histr(lats,lons,units)` specifies the standard angle unit string. The default value is `'degrees'`.

`[lat,lon,num,wnum] = histr(lats,lons,bindensty)` sets the number of bins per angular unit. For example, if *`units`* is `'degrees'`, a *`bindensty`* of 10 would be 10 bins per degree of latitude or longitude, resulting in 100 bins per *square* degree. The default is one cell per angular unit.

The `histr` function sorts geographic data into equirectangular bins for histogram purposes. Equirectangular in this context means that each bin has the same angular measurement on each side (e.g., 1°-by-1°). Consequently, the result is not an equal-area histogram. The `hista` function provides that capability. However, the results of `histr` can be weighted by their area bias to correct for this, in some sense.

Examples

Create random data:

```
lats = rand(4)

lats =
    0.4451    0.8462    0.8381    0.8318
    0.9318    0.5252    0.0196    0.5028
    0.4660    0.2026    0.6813    0.7095
    0.4186    0.6721    0.3795    0.4289
```

```
longs = rand(4)

longs =
    0.3046    0.3028    0.3784    0.4966
    0.1897    0.5417    0.8600    0.8998
    0.1934    0.1509    0.8537    0.8216
    0.6822    0.6979    0.5936    0.6449
```

Bin the data in 0.5-by-0.5 degree cells (two bins per degree):

```
[lat,lon,num,wnum] = histr(lats,longs,2);
[lat,lon,num,wnum]

ans =
    0.2500    0.2500    3.0000    3.0000
    0.7500    0.2500    4.0000    4.0003
    0.2500    0.7500    4.0000    4.0000
    0.7500    0.7500    5.0000    5.0004
```

The bins centered at 0.75°N are slightly smaller in area than the others. `wnum` reflects the relative count per normalized unit area.

See Also

`filterm` | `hista`

Purpose

Encode data points into regular data grid

Syntax

```
Z = imbedm(lat, lon, value, Z, R)
Z = imbedm(lat, lon, value, Z, R, units)
[Z, indxPointOutsideGrid] = imbedm(...)
```

Description

`Z = imbedm(lat, lon, value, Z, R)` resets certain entries of a regular data grid, `Z`. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to or from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Nearest-neighbor interpolation is used by default. NaN is returned for points outside the grid limits or for which `lat` or `lon` contain NaN. All angles are in units of degrees.

`Z = imbedm(lat, lon, value, Z, R, units)` specifies the units of the vectors `lat` and `lon`, where *`units`* is any valid angle units string (`'degrees'` by default).

`[Z, indxPointOutsideGrid] = imbedm(...)` returns the indices of `lat` and `lon` corresponding to points outside the grid in the variable `indxPointOutsideGrid`.

Examples

Create a simple grid map and embed new values in it:

```
Z = ones(3,6)

Z =
     1     1     1     1     1     1
     1     1     1     1     1     1
     1     1     1     1     1     1
refvec = [1/60 90 -180]

refvec =
    0.0167   90.0000 -180.0000

newgrid = imbedm([23 -23], [45 -45],[5 5],Z,refvec)

newgrid =
     1     1     1     1     1     1
     1     1     5     5     1     1
     1     1     1     1     1     1
```

See Also

`ltln2val` | `setpostn`

Purpose

Convert indexed image to uint8 RGB image

Syntax

```
RGB = ind2rgb8(X,cmap)
```

Description

`RGB = ind2rgb8(X,cmap)` creates an RGB image of class `uint8`. `X` must be `uint8`, `uint16`, or `double`, and `cmap` must be a valid MATLAB colormap.

Examples

```
% Convert the 'concord_ortho_e.tif' image to RGB.
[X, cmap] = imread('concord_ortho_e.tif');
RGB = ind2rgb8(X, cmap);
R = worldfileread('concord_ortho_e.tfw');
mapshow(RGB, R);
```

See Also

`ind2rgb`

ingeoquad

Purpose

True for points inside or on lat-lon quadrangle

Syntax

```
tf = ingeoquad(lat, lon, latlim, lonlim)
```

Description

`tf = ingeoquad(lat, lon, latlim, lonlim)` returns an array `tf` that has the same size as `lat` and `lon`. `tf(k)` is true if and only if the point `lat(k)`, `lon(k)` falls within or on the edge of the geographic quadrangle defined by `latlim` and `lonlim`. `latlim` is a vector of the form `[southern-limit northern-limit]`, and `lonlim` is a vector of the form `[western-limit eastern-limit]`. All angles are in units of degrees.

Examples

1. Load and display a digital elevation model (DEM) including the Korean Peninsula:

```
korea = load('korea');
R = refvecToGeoRasterReference(korea.refvec, size(korea.map));
figure('Color','white')
worldmap([20 50],[90 150])
geoshow(korea.map, R, 'DisplayType', 'texturemap');
demcmap(korea.map)
```

2. Outline the quadrangle containing the DEM:

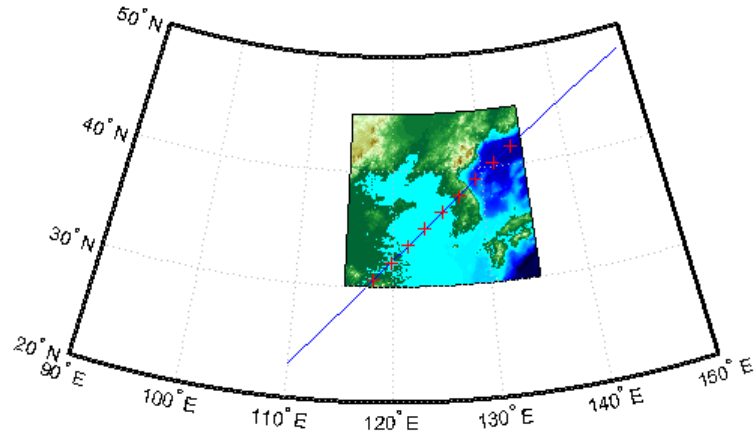
```
[outlineLat, outlineLon] = outlinegeoquad(R.Latlim, ...
   R.Lonlim, 90, 5);
geoshow(outlineLat,outlineLon,'DisplayType','line', ...
   'Color','black')
```

3. Generate a track that crosses the DEM:

```
[lat, lon] = track2(23, 110, 48, 149, [1 0], 'degrees', 20);
geoshow(lat, lon, 'DisplayType', 'line')
```

4. Identify and mark points on the track that fall within the quadrangle outlining the DEM:

```
tf = ingeoquad(lat, lon, R.Latlim, R.Lonlim);
geoshow(lat(tf), lon(tf), 'DisplayType', 'point')
```



See Also

inpolygon | intersectgeoquad

intersectgeoquad

Purpose

Intersection of two latitude-longitude quadrangles

Syntax

```
[latlim, lonlim] = intersectgeoquad(latlim1, lonlim1, latlim2,
   lonlim2)
```

Description

`[latlim, lonlim] = intersectgeoquad(latlim1, lonlim1, latlim2, lonlim2)` computes the intersection of the quadrangle defined by the latitude and longitude limits `latlim1` and `lonlim1`, with the quadrangle defined by the latitude and longitude limits `latlim2` and `lonlim2`. `latlim1` and `latlim2` are two-element vectors of the form `[southern-limit northern-limit]`. Likewise, `lonlim1` and `lonlim2` are two-element vectors of the form `[western-limit eastern-limit]`. All input and output angles are in units of degrees. The intersection results are given in the output arrays `latlim` and `lonlim`. Given an arbitrary pair of input quadrangles, there are three possible results:

1. *The quadrangles fail to intersect.* In this case, both `latlim` and `lonlim` are empty arrays.

2. *The intersection consists of a single quadrangle.* In this case, `latlim` (like `latlim1` and `latlim2`) is a two-element vector that has the form `[southern-limit northern-limit]`, where `southern-limit` and `northern-limit` represent scalar values. `lonlim` (like `lonlim1` and `lonlim2`), is a two-element vector that has the form `[western-limit eastern-limit]`, with a pair of scalar limits.

3. *The intersection consists of a pair of quadrangles.* This can happen when longitudes wrap around such that the eastern end of one quadrangle overlaps the western end of the other and vice versa. For example, if `lonlim1 = [-90 90]` and `lonlim2 = [45 -45]`, there are two intervals of overlap: `[-90 -45]` and `[45 90]`. These limits are returned in `lonlim` in separate rows, forming a 2-by-2 array. In our example (assuming that the latitude limits overlap), `lonlim` would equal `[-90 -45; 45 90]`. It still has the form `[western-limit eastern-limit]`, but `western-limit` and `eastern-limit` are 2-by-1 rather than scalar. The two output quadrangles have the same latitude limits, but these are replicated so that `latlim` is also 2-by-2.

To continue the example, if `latlim1 = [0 30]` and `latlim2 = [20 50]`, `latlim` equals `[20 30; 20 30]`. The form is still `[southern-limit northern-limit]`, but in this case `southern-limit` and `northern-limit` are 2-by-1.

Tips

`latlim1` and `latlim2` should normally be given in order of increasing numerical value. No error will result if, for example, `latlim1(2) < latlim1(1)`, but the outputs will both be empty arrays.

No such restriction applies to `lonlim1` and `lonlim2`. The first element is always interpreted as the western limit, even if it exceeds the second element (the eastern limit). Furthermore, `intersectgeoquad` correctly handles whatever longitude-wrapping convention may have been applied to `lonlim1` and `lonlim2`.

In terms of output, `intersectgeoquad` wraps `lonlim` such that all elements fall in the closed interval `[-180 180]`. This means that if (one of) the output quadrangle(s) crosses the 180° meridian, its western limit exceeds its eastern limit. The result would be such that

```
lonlim(2) < lonlim(1)
```

if the intersection comprises a single quadrangle or

```
lonlim(k,2) < lonlim(k,1)
```

where `k` equals 1 or 2 if the intersection comprises a pair of quadrangles.

If `abs(diff(lonlim1))` or `abs(diff(lonlim2))` equals `360`, its quadrangle is interpreted as a latitudinal zone that fully encircles the planet, bounded only by one parallel on the south and another parallel on the north. If two such quadrangles intersect, `lonlim` is set to `[-180 180]`.

If you want to display geographic quadrangles generated by this function or any other which are more than one or two degrees in extent, they may not follow curved meridians and parallels very well. The degree of departure depends on the extent of the quadrangle, the map projection, and the map scale. In such cases, you can interpolate

intermediate vertices along quadrangle edges with the `outlinegeoquad` function.

Examples

Example 1

Nonintersecting quadrangles:

```
[latlim, lonlim] = intersectgeoquad( ...
                   [-40 -60], [-180 180], [40 60], [-180 180])
latlim =
     []

lonlim =
     []
```

Example 2

Intersection is a single quadrangle:

```
[latlim, lonlim] = intersectgeoquad( ...
                   [-40 60], [-120 45], [-60 40], [160 -75])

latlim =
   -40    40

lonlim =
  -120   -75
```

Example 3

Intersection is a pair of quadrangles:

```
[latlim, lonlim] = intersectgeoquad( ...
                   [-30 90],[-10 -170],[-90 30],[170 10])

latlim =
   -30    30
   -30    30
```

```
lonlim =
   -10    10
   170  -170
```

Example 4

Inputs and output fully encircle the planet:

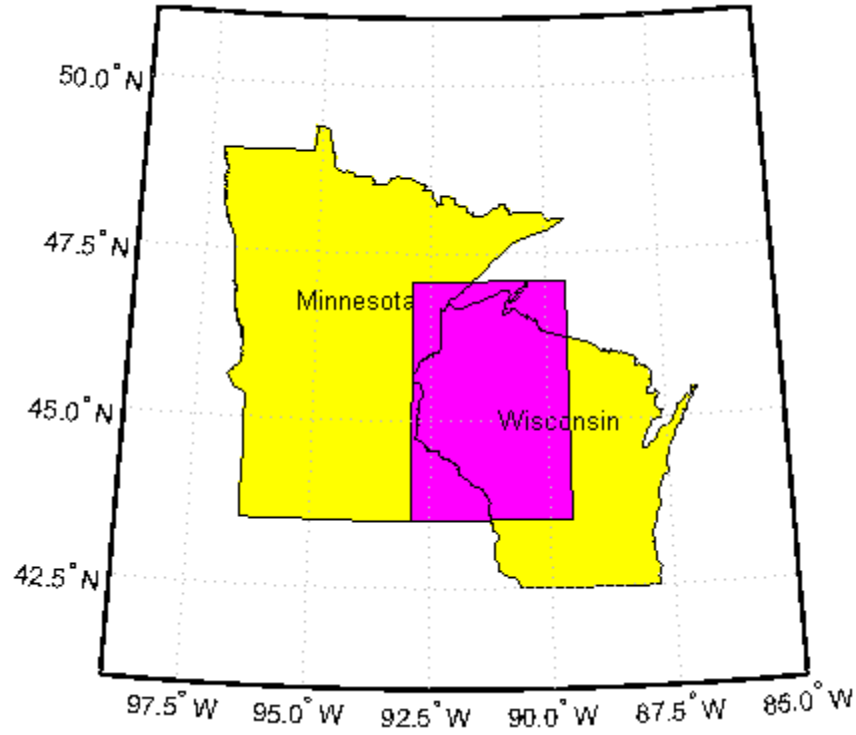
```
[latlim, lonlim] = intersectgeoquad( ...
                   [-30 90],[-180 180],[-90 30],[0 360])

latlim =
   -30    30

lonlim =
  -180   180
```

Example 5

Find and map the intersection of the bounding boxes of adjoining U.S. states:

```
usamap({'Minnesota','Wisconsin'})
S = shaperead('usastatehi','UseGeoCoords',true,'Selector',...
    {@(name) any(strcmp(name,{'Minnesota','Wisconsin'})), 'Name'});
geoshow(S, 'FaceColor', 'y')
textm([S.LabelLat], [S.LabelLon], {S.Name},...
    'HorizontalAlignment', 'center')
latlimMN = S(1).BoundingBox(:,2)'

latlimMN =
   43.4995   49.3844

lonlimMN = S(1).BoundingBox(:,1)'

lonlimMN =
  -97.2385  -89.5612
```

```
latlimWI = S(2).BoundingBox(:,2)'

latlimWI =
   42.4918   47.0773

lonlimWI = S(2).BoundingBox(:,1)'

lonlimWI =
  -92.8892  -86.8059

[latlim lonlim] = ...
    intersectgeoquad(latlimMN, lonlimMN, latlimWI, lonlimWI)

latlim =
   43.4995   47.0773

lonlim =
  -92.8892  -89.5612

geoshow(latlim([1 2 2 1 1]), lonlim([1 1 2 2 1]), ...
    'DisplayType','polygon','FaceColor','m')
```



See Also `ingeoquad` | `outlinegeoquad`

inputm

Purpose

Latitudes and longitudes of mouse-click locations

Syntax

```
[lat, lon] = inputm
[lat, lon] = inputm(n)
[lat, lon] = inputm(n,h)
[lat, lon, button] = inputm(n)
MAT = imputm(...)
```

Description

`[lat, lon] = inputm` returns the latitudes and longitudes in geographic coordinates of points selected by mouse clicks on a displayed grid. The point selection continues until the return key is pressed.

`[lat, lon] = inputm(n)` returns `n` points specified by mouse clicks.

`[lat, lon] = inputm(n,h)` prompts for points from the map axes specified by the handle `h`. If omitted, the current axes (gca) is assumed.

`[lat, lon, button] = inputm(n)` returns a third result, `button`, that contains a vector of integers specifying which mouse button was used (1,2,3 from left) or ASCII numbers if a key on the keyboard was used.

`MAT = imputm(...)` returns a single matrix, where `MAT = [lat lon]`.

Tips

`inputm` works much like the standard MATLAB `ginput`, except that the returned values are latitudes and longitudes extracted from the projection, rather than axes *x*-*y* coordinates. If you click outside of the projection bounds (beyond the map frame in the corners of a Robinson projection, for example), no coordinates are returned for that location.

`inputm` cannot be used with a 3-D display, including those created using `globe`.

See Also

`gcpmap` | `ginput`

Purpose

Densify latitude-longitude sampling in lines or polygons

Syntax

```
[latout,lonout] = interpm(lat,lon,maxdiff)
[latout,lonout] = interpm(lat,lon,maxdiff,method)
[latout,lonout] = interpm(lat,lon,maxdiff,method,units)
```

Description

`[latout,lonout] = interpm(lat,lon,maxdiff)` fills in any gaps in latitude (`lat`) or longitude (`lon`) data vectors that are greater than a defined tolerance `maxdiff` apart in either dimension. The angle units of the three inputs need not be specified, but they must be identical. `latout` and `lonout` are the new latitude and longitude data vectors, in which any gaps larger than `maxdiff` in the original vectors have been filled with additional points. The default method of interpolation used by `interpm` is linear.

`[latout,lonout] = interpm(lat,lon,maxdiff,`*`method`*`)` interpolates between vector data coordinate points using a specified interpolation method. Valid interpolation method strings are `'gc'` for great circle, `'rh'` for rhumb line, and `'lin'` for linear interpolation.

`[latout,lonout] = interpm(lat,lon,maxdiff,`*`method`*`,units)` specifies the units used, where *`units`* is any valid angle units string. The default is `'degrees'`.

Examples

```
lat = [1 2 4 5]; lon = [7 8 9 11];
[latout,lonout] = interpm(lat,lon,1);
[latout lonout]

ans =
    1.0000    7.0000
    2.0000    8.0000
    3.0000    8.5000
    4.0000    9.0000
    4.5000   10.0000
    5.0000   11.0000
```

See Also

`intrplat` | `intrplon`

intrplat

Purpose

Interpolate latitude at given longitude

Syntax

```
newlat = intrplat(long,lat,newlong)
newlat = intrplat(long,lat,newlong,method)
newlat = intrplat(long,lat,newlong,method,units)
```

Description

`newlat = intrplat(long,lat,newlong)` returns an interpolated latitude, `newlat`, corresponding to a longitude `newlong`. `long` must be a monotonic vector of longitude values. The actual entries must be monotonic; that is, the longitude vector `[350 357 3 10]` is not allowed even though the geographic *direction* is unchanged (use `[350 357 363 370]` instead). `lat` is a vector of the latitude values paired with each entry in `long`.

`newlat = intrplat(long,lat,newlong,method)` specifies the method of interpolation employed, listed in the table below.

Method	Description
`'linear'`	Linear, or Cartesian, interpolation (default)
`'pchip'`	Piecewise cubic Hermite interpolation
`'rh'`	Returns interpolated points that lie on rhumb lines between input data
`'gc'`	Returns interpolated points that lie on great circles between input data

`newlat = intrplat(long,lat,newlong,method,units)` specifies the units used, where *`units`* is any valid angle units string. The default is `'degrees'`.

The function `intrplat` is a geographic data analogy of the standard MATLAB function `interp1`.

Examples

Compare the results of the various methods:

```
lats = [25 45]; longs = [30 60];
newlat = intrplat(longs,lats,45,'linear')
```

```
newlat =
    35

newlat = intrplat(longs,lats,45,'rh')

newlat =
   35.6213

newlat = intrplat(longs,lats,45,'gc')

newlat =
   37.1991
```

Tips

There are separate functions for interpolating latitudes and longitudes, for although the cases are identical when using those methods supported by `interp1`, when latitudes and longitudes are treated like the spherical angles they are (using `'rh'` or `'gc'`), the results are different. Compare the example above to the example under `intrplon`, which reverses the values of latitude and longitude.

See Also

`interpm` | `intrplon`

intrplon

Purpose

Interpolate longitude at given latitude

Syntax

```
newlon = intrplon(lat,lon,newlat)
newlon = intrplon(lat,lon,newlat,method)
newlon = intrplon(lat,lon,newlat,method,units)
```

Description

`newlon = intrplon(lat,lon,newlat)` returns an interpolated longitude, `newlon`, corresponding to a latitude `newlat`. `lat` must be a monotonic vector of longitude values. `lon` is a vector of the longitude values paired with each entry in `lat`.

`newlon = intrplon(lat,lon,newlat,method)` specifies the method of interpolation employed, listed in the table below.

Method	Description
`'linear'`	Linear, or Cartesian, interpolation (default)
`'pchip'`	Piecewise cubic Hermite interpolation
`'rh'`	Returns interpolated points that lie on rhumb lines between input data
`'gc'`	Returns interpolated points that lie on great circles between input data

`newlon = intrplon(lat,lon,newlat,method,units)` specifies the units used, where *`units`* is any valid angle units string. The default is `'degrees'`.

The function `intrplon` is a geographic data analogy of the MATLAB function `interp1`.

Examples

Compare the results of the various methods:

```
long = [25 45]; lat = [30 60];
newlon = intrplon(lat,long,45,'linear')

newlon =
    35
```

```
newlon = intrplon(lat,long,45,'rh')

newlon =
   33.6515

newlon = intrplon(lat,long,45,'gc')

newlon =
   32.0526
```

Tips

There are separate functions for interpolating latitudes and longitudes, for although the cases are identical when using those methods supported by `interp1`, when latitudes and longitudes are treated like the spherical angles they are (using `'rh'` or `'gc'`), the results are different. Compare the previous example to the example under `intrplat`, which reverses the values of latitude and longitude.

See Also

`interpm` | `intrplat`

ismap

Purpose

True for axes with map projection

Syntax

```
mflag = ismap
mflag = ismap(hndl)
[mflag,msg] = ismap(hndl)
```

Description

`mflag = ismap` returns a 1 if the current axes is a map axes, and 0 otherwise.

`mflag = ismap(hndl)` specifies the handle of the axes to be tested.

`[mflag,msg] = ismap(hndl)` returns a string message if the axes is not a map axes, specifying why not.

The `ismap` function tests an axes object to determine whether it is a map axes.

See Also

`gcm | ismapped`

Purpose

True, if object is projected on map axes

Syntax

```
mflag = ismapped
mflag = ismapped(hndl)
[mflag,msg] = ismapped(hndl)
```

Description

`mflag = ismapped` returns a 1 if the current object is projected on a map axes, and 0 otherwise.

`mflag = ismapped(hndl)` specifies the handle of the object to be tested.

`[mflag,msg] = ismapped(hndl)` returns a string message if the axes is not projected on a map axes, specifying why not.

The `ismapped` function tests an object to determine whether it is projected on map axes.

See Also

`gcm | ismap`

ispolycw

Purpose

True if polygon vertices are in clockwise order

Syntax

```
tf = ispolycw(x, y)
```

Description

`tf = ispolycw(x, y)` returns true if the polygonal contour vertices represented by `x` and `y` are ordered in the clockwise direction. `x` and `y` are numeric vectors with the same number of elements.

Alternatively, `x` and `y` can contain multiple contours, either in `NaN`-separated vector form or in cell array form. In that case, `ispolycw` returns a logical array containing one true or false value per contour.

`ispolycw` always returns true for polygonal contours containing two or fewer vertices.

Vertex ordering is not well defined for self-intersecting polygonal contours. For such contours, `ispolycw` returns a result based on the order or vertices immediately before and after the left-most of the lowest vertices. In other words, of the vertices with the lowest `y` value, find the vertex with the lowest `x` value. For a few special cases of self-intersecting contours, the vertex ordering cannot be determined using only the left-most of the lowest vertices; for these cases, `ispolycw` uses a signed area test to determine the ordering.

Class Support

`x` and `y` may be any numeric class.

Examples

Orientation of a square:

```
x = [0 1 1 0 0];
y = [0 0 1 1 0];
ispolycw(x, y)                      % Returns 0
ispolycw(fliplr(x), fliplr(y))      % Returns 1
```

See Also

`poly2cw` | `poly2ccw` | `polybool`

Purpose

True if polygon or line has multiple parts

Syntax

```
tf = isShapeMultipart(xdata, ydata)
```

Description

`tf = isShapeMultipart(xdata, ydata)` returns `1` (`true`) if the polygon or line shape specified by `xdata` and `ydata` consists of multiple `NaN`-separated parts (i.e. has inner or multiple polygon rings or multiple line segments). The coordinate arrays `xdata` and `ydata` must match in size and have identical `NaN` locations.

Examples

```
isShapeMultipart([0 0 1],[0 1 0])

ans =
     0

isShapeMultipart([0 0 1 NaN 2 2 3 3],[0 1 0 NaN 2 3 3 2])

ans =
     1

load coast
isShapeMultipart(lat, long)

ans =
     1

S = shaperead('concord_hydro_area');
isShapeMultipart( S(1).X,  S(1).Y)

ans =
     0

isShapeMultipart(S(14).X, S(14).Y)

ans =
     1
```

See Also `polysplit`

Purpose

Convert distance from kilometers to degrees

Syntax

```
deg = km2deg(km)
deg = km2deg(km,radius)
deg = km2deg(km,sphere)
```

Description

`deg = km2deg(km)` converts distances from kilometers to degrees as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`deg = km2deg(km,radius)` converts distances from kilometers to degrees as measured along a great circle on a sphere having the specified radius. `radius` must be in units of kilometers.

`deg = km2deg(km,sphere)` converts distances from kilometers to degrees, as measured along a great circle on a sphere approximating an object in the Solar System. *`sphere`* may be one of the following strings: `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'earth'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, or `'pluto'`, and is case-insensitive.

Examples

Two cities are 340 km apart. How many degrees of arc is that? How many degrees would it be if the cities were on Mars?

```
deg = km2deg(340)

deg =
    3.0577

deg = km2deg(340,'mars')

deg =
    5.7465
```

See Also

`degtorad` | `radtodeg` | `deg2km` | `km2rad` | `km2nm` | `km2sm` | `deg2nm` | `nm2deg` | `nm2km` | `nm2sm` | `deg2sm` | `sm2deg` | `sm2km` | `sm2nm`

km2nm

Purpose

Convert kilometers to nautical miles

Syntax

```
nm = km2nm(km)
```

Description

`nm = km2nm(km)` converts distances from kilometers to nautical miles.

See Also

`deg2km` | `km2deg` | `km2rad` | `rad2km` | `deg2nm` | `nm2deg` | `nm2rad` | `rad2nm` | `deg2sm` | `sm2deg` | `deg2sm` | `sm2rad` | `rad2sm`

Purpose

Convert distance from kilometers to radians

Syntax

```
rad = km2rad(km)
rad = km2rad(km,radius)
rad = km2rad(km,sphere)
```

Description

`rad = km2rad(km)` converts distances from kilometers to radians as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`rad = km2rad(km,radius)` converts distances from kilometers to radians as measured along a great circle on a sphere having the specified radius. `radius` must be in units of kilometers.

`rad = km2rad(km,sphere)`converts distances from kilometers to radians , as measured along a great circle on a sphere approximating an object in the Solar System. *`sphere`* may be one of the following strings: `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'earth'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, or `'pluto'`, and is case-insensitive.

Examples

How many radians does 1,000 km span on the Earth and on the Moon?

```
rad = km2rad(1000)

rad =
    0.1570

rad = km2rad(1000,'moon')

rad =
    0.5754
```

See Also

`degtorad` | `radtodeg` | `rad2km` | `km2deg` | `km2nm` | `km2sm` | `rad2nm` | `nm2deg` | `nm2km` | `nm2sm` | `rad2sm` | `sm2deg` | `sm2km` | `sm2nm`

km2sm

Purpose

Convert kilometers to statute miles

Syntax

```
sm = km2sm(km)
```

Description

`sm = km2sm(km)` converts distances from kilometers to statute miles.

Examples

How many statute miles is a 10k run?

```
sm = km2sm(10)

sm =
    6.2137
```

See Also

`deg2km` | `km2deg` | `km2rad` | `rad2km` | `deg2nm` | `nm2deg` | `nm2rad` | `rad2nm` | `deg2sm` | `sm2deg` | `deg2sm` | `sm2rad` | `rad2sm`

Purpose

Write geographic data to KML file

Syntax

```
kmlwrite(filename, lat, lon)
kmlwrite(filename, S)
kmlwrite(filename, address)
kmlwrite(..., param1, val1, param2, val2, ...)
```

Description

`kmlwrite(filename, lat, lon)` writes the latitude and longitude points `lat` and `lon` to disk in KML format. KML stands for Keyhole Markup Language. It is an XML dialect used by the Google Earth™ and Google Maps™ mapping services and similar applications. `lat` and `lon` are numeric vectors, specified in degrees. `lat` must be in the range `[-90, 90]`. There is no range constraint on `lon`; all longitudes are automatically wrapped to the range `[-180, 180]`, to adhere to the KML specification. `filename` must be a character string specifying the output file name and location. If an extension is included, it must be `.kml`.

`kmlwrite(filename, S)` writes a point or multipoint geostruct to disk in KML format. The `Geometry` field of `S` must be either `'Point'` or `'Multipoint'`. `S` must include `Lat` and `Lon` fields. (If `S` includes `X` and `Y` fields an error is issued). The attribute fields of `S` are presented as a table in the description tag of the placemark displayed for each element of `S`, in the same order as they appear in `S`.

`kmlwrite(filename, address)` specifies the location of a KML Placemark via an `address` string or cell array of strings. Each string represents an unstructured address with city, state, and/or postal code. If `address` is a cell array, each cell contains the address of a unique point.

`kmlwrite(..., param1, val1, param2, val2, ...)` specifies parameter-value pairs that set additional KML feature properties. Parameter names can be abbreviated and are case-insensitive.

The parameter-value pairs are listed below:

- `Name` — A string or cell array of strings that specifies a name displayed in the viewer as the label for the object. If the value is a

string, the name is applied to all objects. If the value is a cell array, it must match in size to `lat` and `lon`, `S`, or `address`.

- `Description` — A string, cell array of strings, or an attribute spec, that specifies the contents to be displayed in the feature's description tag(s). The description appears in the description balloon when the user clicks either the feature name in the Google Earth application Places panel or clicks the placemark icon in the viewer window. If the value is a string, the description is applied to all objects. If the value is a cell array, it must match the size of `lat` and `lon`, `S`, or `address`. Use a cell array to customize descriptive tags for different placemarks.

  Description elements can be either plain text or marked up with HTML. When it is plain text, the Google Earth application applies basic formatting, replacing each `newline` with `<br>` and giving anchor tags to all valid URLs for the World Wide Web. The URL strings are converted to hyperlinks. This means that you do not need to surround a URL with `<A HREF>` tags in order to create a simple link. Examples of HTML tags recognized by the Google Earth application are provided on its Web site, `http://earth.google.com`.

- `Icon` — A string or cell array of strings that specifies a custom icon filename. If the value is a string, the value is applied to all objects. If the value is a cell array, it must have the same size as `lat` and `lon`, `S`, or `address`. If the icon filename is not in the current folder, or in a folder on the MATLAB path, specify a full or relative path name. The string can be an Internet URL. The URL must include the protocol prefix (e.g., `http://`).

- `IconScale` — A positive numeric scalar or array that specifies a scaling factor for the icon. If the value is a scalar, the value is applied to all objects. If the value is an array, it must have the same size as `lat` and `lon`, `S`, or `address`.

Tips

Using an Attribute Spec to Control Formatting of Attributes

An attribute spec is a structure with field names of attributes that controls how the table is displayed in its description balloon. In

it, each field name you want to display has two fields, `Format` and `AttributeLabel`.

When you provide geostruct, `S`, to `kmlwrite`, then the `Description` parameter can be an attribute spec. In this case, the attribute fields of `S` are displayed as a table in the description tag of the placemark for each element of `S`. (If you specify an attribute spec with `lat` and `lon` input syntax, the attribute spec is ignored.) The attribute spec can control:

- Which attributes are included in the table
- The name for the attribute
- The order in which attributes appear
- The formatting of attributes

The easiest way to construct an attribute spec is to call `makeattribspec`, and then modify the output to remove attributes or change the Format field for one or more attributes. The `lat` and `lon` fields of `S` are never treated as attributes.

Viewing the KML file with the Google Earth browser

A KML file may be displayed in a Google Earth browser. The Google Earth application must be installed on the system. On Microsoft® Windows platforms you can display the KML file with:

```
winopen(filename)
```

For Unix and MAC users, display the KML file with:

```
cmd = 'googleearth ';
fullfilename = fullfile(pwd, filename);
system([cmd fullfilename])
```

Viewing the KML file with a Web Browser

You can view KML files using the Google Maps mapping service in addition to using an installed Google Earth application. To do so, the file must be located on a web server that is accessible from the Internet. A private intranet server will not suffice, because the Google Maps server must be able to access the URL that you provide to it. Here is

a template for viewing your KML in a browser window via the Google Maps mapping service:

```
GMAPS_URL = 'http://maps.google.com/maps?q=';
KML_URL = 'http://<your web server and path to your KML file>';
web([GMAPS KML_URL])
```

You can only display a limited number of placemarks on a Google Maps page, and all placemarks must be geolocated using latitude-longitude coordinates (address-based placemarks are not supported). Google Mobile™ has further restrictions. See the Google KML documentation for more information.

Examples

Example 1 — Write a single point to a KML file

Add a description containing HTML markup, a name, and provide the location of an icon to display. Specifying an icon as a URL from the Web (as opposed to specifying one from a local file) makes the icon accessible to users of Google Maps service as well as to Google Earth users.

```
% Write a single point to a KML file.
% Add a description containing HTML, a name and an icon.
lat =  42.299827;
lon = -71.350273;
description = sprintf('%s<br>%s</br><br>%s</br>', ...
       '3 Apple Hill Drive', 'Natick, MA. 01760', ...
       'http://www.mathworks.com');
name = 'The MathWorks, Inc.';
filename = 'MathWorks.kml';
kmlwrite(filename, lat, lon, ...
       'Description', description, 'Name', name, 'Icon', ...
'http://www.mathworks.com/products/product_listing/images/ml_icon.gif');
```

Example 2 — Write the locations of major European cities to a KML file

Include the names of the cities, and remove the default description table:

```
latlim = [ 30; 75];
lonlim = [-25; 45];
cities = shaperead('worldcities.shp','UseGeoCoords', true, ...
    'BoundingBox', [lonlim, latlim]);
filename = 'European_Cities.kml';
kmlwrite(filename, cities, 'Name', {cities.Name}, 'Description',{});
```

Example 3 — Write the locations of several Australian cities to a KML file

List the addresses to be displayed in a cell array:

```
address = {'Perth, Australia', ...
           'Melbourne, Australia', ...
           'Sydney, Australia'};
filename = 'Australian_Cities.kml';
kmlwrite(filename, address, 'Name', address);
```

Example 4 — Unproject locations of Boston landmarks and write to a KML file

The Boston placenames file contains points stored in projected coordinates of meters, but Earth browsers require geographic coordinates (latitudes and longitudes). Begin by converting coordinates from meters to survey feet, inverting the projection to latitudes and longitudes, and then adding the latitudes and longitudes to the geostruct. To unproject properly, use the projection information extracted from the GeoTIFF file `boston.tif`:

```
S = shaperead('boston_placenames');
proj = geotiffinfo('boston.tif');
surveyFeetPerMeter = unitsratio('sf','meter');
for k=1:numel(S)
    x =  surveyFeetPerMeter * S(k).X;
    y =  surveyFeetPerMeter * S(k).Y;
    [S(k).Lat, S(k).Lon] = projinv(proj, x, y);
end
filename = 'Boston_Placenames.kml';
```

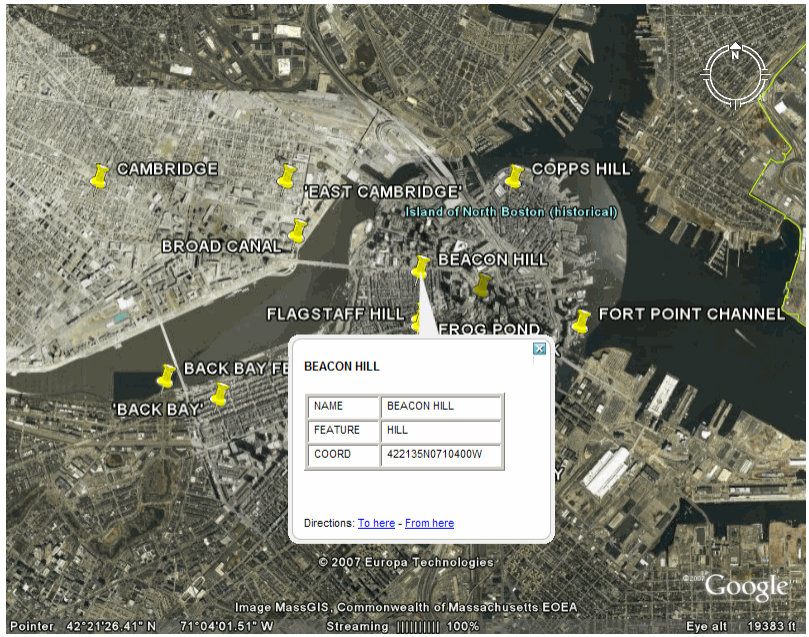
```
kmlwrite(filename, S, 'Name', {S.NAME});
```

If you have the Google Earth application installed, you can view the file on Microsoft Windows as follows:

```
winopen(filename)
```

On UNIX or MAC, use:

```
cmd = 'googleearth ';
fullfilename = fullfile(pwd, filename);
system([cmd fullfilename])
```



For a different view of this location and placename data, see “Tour Boston with the Map Viewer”.

See Also

geoshow | makeattribspec | shaperead | shapewrite

latlon2pix

Purpose

Convert latitude-longitude coordinates to pixel coordinates

Syntax

```
[row, col ] = latlon2pix(R,lat,lon)
```

Description

`[row, col ] = latlon2pix(R,lat,lon)` calculates pixel coordinates `row`, `col` from latitude-longitude coordinates `lat`, `lon`. `R` is either a 3-by-2 referencing matrix that transforms intrinsic pixel coordinates to geographic coordinates, or a `spatialref.GeoRasterReference` object. `lat` and `lon` are vectors or arrays of matching size. The outputs `row` and `col` have the same size as `lat` and `lon`. `lat` and `lon` must be in degrees.

Longitude wrapping is handled in the following way: Results are invariant under the substitution `lon = lon +/- n * 360` where `n` is an integer. Any point on the Earth that is included in the image or gridded data set corresponding to `r` will yield row/column values between 0.5 and 0.5 + the image height/width, regardless of what longitude convention is used.

Examples

Find the pixel coordinates of the upper left and lower right outer corners of a 2-by-2 degree gridded data set.

```
R = makerefmat(1, 89, 2, 2);
[UL_row, UL_col] = latlon2pix(R,  90, 0)     % Upper left
[LR_row, LR_col] = latlon2pix(R, -90, 360)   % Lower right
[LL_row, LL_col] = latlon2pix(R, -90, 0)     % Lower left
```

Note that the in both the 2nd case and 3rd case we get a column value of 0.5, because the left and right edges are on the same meridian and (-90, 360) is the same point as (-90, 0).

See Also

`map2pix` | `makerefmat` | `pix2latlon`

Purpose

Colorbar with text labels

Syntax

```
lcolorbar(labels)
lcolorbar(labels,'property',value,...)
hcb = lcolorbar(...)
```

Description

`lcolorbar(labels)` appends a colorbar with text labels. The labels input is a cell array of label strings. The colorbar is constructed using the current colormap with the label strings applied at the centers of the color bands.

`lcolorbar(labels,'property',value,...)` controls the colorbar's properties. The location of the colorbar is controlled by the `Location` property. Valid entries for `Location` are `'vertical'` (the default) or `'horizontal'`. Properties `TitleString`, `XLabelString`, `YLabelString` and `ZLabelString` set the respective strings. Property `ColorAlignment` controls whether the colorbar labels are centered on the color bands or the color breaks. Valid values for `ColorAlignment` are `'center'` and `'ends'`.

Other valid property-value pairs are any properties and values that can be applied to the title and labels of the colorbar axes.

`hcb = lcolorbar(...)` returns a handle to the colorbar axes.

Examples

```
figure; colormap(jet(5))
labels = {'apples','oranges','grapes','peachs','melons'};
lcolorbar(labels,'fontweight','bold');
```

See Also

`contourcmap` | `colormapeditor`

legs

Purpose

Courses and distances between navigational waypoints

Syntax

```
[course,dist] = legs(lat,lon)
[course,dist] = legs(lat,lon,method)
[course,dist] = legs(pts) and [course,dist] = legs(pts,
   method)
mat = legs(lat,...)
```

Description

`[course,dist] = legs(lat,lon)` returns the azimuths (`course`) and distances (`dist`) between navigational waypoints, which are specified by the column vectors `lat` and `lon`.

`[course,dist] = legs(lat,lon,method)` specifies the logic for the leg characteristics. If the string *`method`* is `'rh'` (the default), `course` and `dist` are calculated in a rhumb line sense. If *`method`* is `'gc'`, great circle calculations are used.

`[course,dist] = legs(pts) and [course,dist] = legs(pts,method)` allow you to input the waypoints in a single two-column matrix, `pts`.

`mat = legs(lat,...)` packs up the outputs into a single two-column matrix, `mat`.

This is a navigation function. All angles are in degrees, and all distances are in nautical miles. Track legs are the courses and distances traveled between navigational waypoints.

Examples

Imagine an airplane taking off from Logan International Airport in Boston (42.3ºN,71ºW) and traveling to LAX in Los Angeles (34ºN,118ºW). The pilot wants to file a flight plan that takes the plane over O'Hare Airport in Chicago (42ºN,88ºW) for a navigational update, while maintaining a constant heading on each of the two legs of the trip.

What are those headings and how long are the legs?

```
lat = [42.3; 42; 34]; long = [-71; -88; -118];
[course,dist] = legs(lat,long,'rh')
```

```
course =
  268.6365
  251.2724
dist =
  1.0e+003 *
    0.7569
    1.4960
```

Upon takeoff, the plane should proceed on a heading of about 269º for 756 nautical miles, then alter course to 251º for another 1495 miles.

How much farther is it traveling by not following a great circle path between waypoints? Using rhumb lines, it is traveling

```
totalrh = sum(dist)

totalrh =
    2.2530e+003
```

For a great circle route,

```
[coursegc,distgc] = legs(lat,long,'gc'); totalgc = sum(distgc)

totalgc =
    2.2451e+003
```

The great circle path is less than one-half of one percent shorter.

See Also

`dreckon` | `gcwaypts` | `navfix` | `track`

lightm

Purpose

Project light objects on map axes

Syntax

```
h = lightm(lat,lon)
h = lightm(lat,lon,PropertyName,PropertyValue,...)
h = lightm(lat,lon,alt)
```

Description

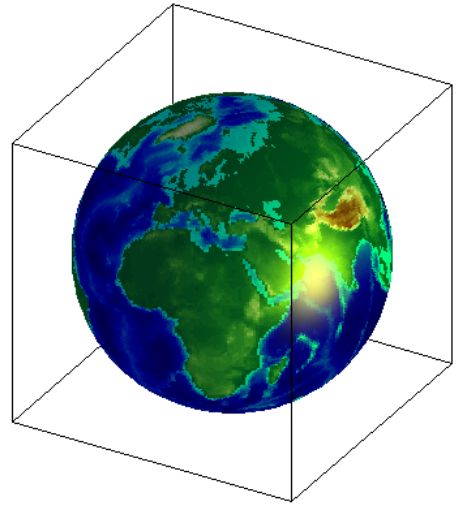
`h = lightm(lat,lon)` projects a light object at the coordinates `lat` and `lon`. The handle, `h`, of the object can be returned.

`h = lightm(lat,lon,PropertyName,PropertyValue,...)` allows the specification of any property name/property value pair supported by the standard MATLAB `light` function.

`h = lightm(lat,lon,alt)` allows the specification of an altitude, `alt`, for the light object. When omitted, the default is an infinite light source altitude.

Examples

```
load topo
axesm globe; view(120,30)
meshm(topo,topolegend); demcmap(topo)
lightm(0,90,'color','yellow')
material([.5 .5 1]); lighting phong
```



See Also

`light` | `lightmui`

limitm

Purpose

Determine latitude and longitude limits of regular data grid

Syntax

```
[latlim,lonlim] = limitm(Z,R)
latlonlim = limitm(Z,R)
```

Description

`[latlim,lonlim] = limitm(Z,R)` computes the latitude and longitude limits of the geographic quadrangle bounding the regular data grid `Z` spatially referenced by `R`. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must also define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. The output `latlim` is a vector of the form `[southern_limit northern_limit]` and `lonlim` is a vector of the form `[western_limit eastern_limit]`. All angles are in units of degrees.

`latlonlim = limitm(Z,R)` concatenates `latlim` and `lonlim` into a 1-by-4 row vector of the form:

```
[southern_limit northern_limit western_limit eastern_limit]
```

Examples

Use a familiar data grid:

```
load topo
[latlimits,lonlimits] = limitm(topo,topolegend)
```

```
latlimits =
   -90    90
lonlimits =
     0   360
```

The result is expected, because `topo` covers the whole globe.

See Also

`makerefmat`

linecirc

Purpose

Intersections of circles and lines in Cartesian plane

Syntax

```
[xout,yout] = linecirc(slope,intercpt,centerx,centery,radius)
```

Description

`[xout,yout] = linecirc(slope,intercpt,centerx,centery,radius)` finds the points of intersection given a circle defined by a center and radius in *x*-*y* coordinates, and a line defined by slope and *y*-intercept, or a slope of "inf" and an *x*-intercept. Two points are returned. When the objects do not intersect, `NaN`s are returned.

When the line is tangent to the circle, two identical points are returned. All inputs must be scalars.

See Also

`circcirc`

Purpose

Project line object on map axes

Syntax

```
h = linem(lat,lon)
h = linem(lat,lon,linetype)
h = linem(lat,lon,PropertyName,PropertyValue,...)
h = linem(lat,lon,z)
```

Description

`h = linem(lat,lon)` displays projected line objects on the current map axes. `lat` and `lon` are the latitude and longitude coordinates, respectively, of the line object to be projected. Note that this ordering is conceptually reversed from the MATLAB `line` function, because the *vertical* (*y*) coordinate comes first. However, the ordering latitude, then longitude, is standard geographic usage. `lat` and `lon` must be the same size and in the `AngleUnits` of the map axes. The object handle for the displayed line can be returned in `h`.

`h = linem(lat,lon,linetype)` allows the specification of the line style, where *`linetype`* is any string recognized by the MATLAB `line` function.

`h = linem(lat,lon,PropertyName,PropertyValue,...)` allows the specification of any number of property name/property value pairs for any properties recognized by the MATLAB `line` function except for `XData`, `YData`, and `ZData`.

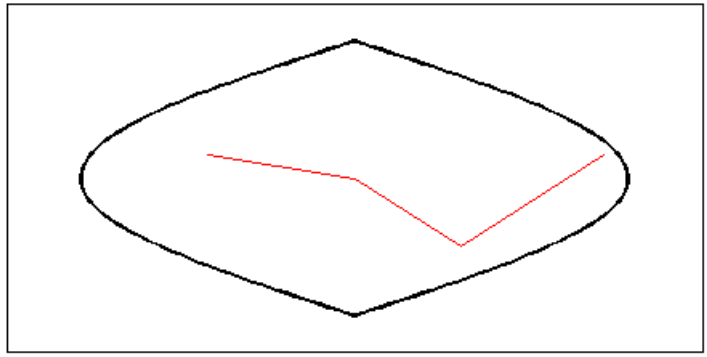
`h = linem(lat,lon,z)` displays a line object in three dimensions, where `z` is the same size as `lat` and `lon` and contains the desired altitude data. `z` is independent of `AngleUnits`. If omitted, all points are assigned a *z*-value of 0 by default.

The units of `z` are arbitrary, except when using the `Globe` projection. In the case of `globe`, `z` should have the same units as the radius of the earth or semimajor axis specified in the `'geoid'` (reference ellipsoid) property of the map axes. This implies that when the reference ellipsoid is a unit sphere, the units of `z` are earth radii.

`linem` is the mapping equivalent of the MATLAB `line` function. It is a low-level graphics function for displaying line objects in map projections. Ordinarily, it is not used directly. Use `plotm` or `plot3m` instead.

Examples

```
axesm sinusoid; framem
linem([15; 0; -45; 15],[-100; 0; 100; 170],'r-')
```



See Also

line | plot3m | plotm

Purpose

Line-of-sight visibility between two points in terrain

Syntax

```
vis = los2(Z,R,lat1,lon1,lat2,lon2)
vis = los2(Z,R,lat1,lon1,lat2,lon2,alt1)
vis = los2(Z,R,lat1,lon1,lat2,lon2,alt1,alt2)
vis = los2(Z,R,lat1,lon1,lat2,lon2,alt1,alt2,alt1opt)
vis = los2(Z,R,lat1,lon1,lat2,lon2,alt1,alt2,alt1opt,alt2opt)
vis = los2(Z,R,lat1,lon1,lat2,lon2,alt1,alt2,alt1opt, ...
  alt2opt,actualradius)
vis = los2(Z,R,lat1,lon1,lat2,lon2,alt1,alt2,alt1opt, ...
  alt2opt,actualradius,effectiveradius)
[vis,visprofile,dist,H,lattrk,lontrk] = los2(...)
los2(...)
```

Description

`los2` computes the mutual visibility between two points on a displayed digital elevation map. `los2` uses the current object if it is a regular data grid, or the first regular data grid found on the current axes. The grid's `zdata` is used for the profile. The color data is used in the absence of data in `z`. The two points are selected by clicking on the map. The result is displayed in a new figure. Markers indicate visible and obscured points along the profile. The profile is shown in a Cartesian coordinate system with the origin at the observer's location. The displayed `z` coordinate accounts for the elevation of the terrain and the curvature of the body.

`vis = los2(Z,R,lat1,lon1,lat2,lon2)` computes the mutual visibility between pairs of points on a digital elevation map. The elevations are provided as a regular data grid `Z` containing elevations in units of meters. The two points are provided as vectors of latitudes and longitudes in units of degrees. The resulting logical variable `vis` is equal to one when the two points are visible to each other, and zero when the line of sight is obscured by terrain. If any of the input arguments are empty, `los2` attempts to gather the data from the current axes. With one or more output arguments, no figures are created and only the data is returned.

`R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix. If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to or from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Nearest-neighbor interpolation is used by default. NaN is returned for points outside the grid limits or for which `lat` or `lon` contain NaN. All angles are in units of degrees.

`vis = los2(Z,R,lat1,lon1,lat2,lon2,alt1)` places the first point at the specified altitude in meters above the surface (on a tower, for instance). This is equivalent to putting the point on a tower. If omitted, point 1 is assumed to be on the surface. `alt1` may be either a scalar or a vector with the same length as `lat1`, `lon1`, `lat2`, and `lon2`.

`vis = los2(Z,R,lat1,lon1,lat2,lon2,alt1,alt2)` places both points at a specified altitudes in meters above the surface. `alt2` may be either a scalar or a vector with the same length as `lat1`, `lon1`, `lat2`, and `lon2`. If `alt2` is omitted, point 2 is assumed to be on the surface.

`vis = los2(Z,R,lat1,lon1,lat2,lon2,alt1,alt2,alt1opt)` controls the interpretation of `alt1` as either a relative altitude (`alt1opt` equals `'AGL'`, the default) or an absolute altitude (`alt1opt` equals `'MSL'`). If the altitude option is `'AGL'`, `alt1` is interpreted as the altitude of point 1 in meters above the terrain (“above ground level”). If `alt1opt` is `'MSL'`, `alt1` is interpreted as altitude above zero (“mean sea level”).

`vis = los2(Z,R,lat1,lon1,lat2,lon2,alt1,alt2,alt1opt,alt2opt)` controls the interpretation `ALT2`.

`vis = los2(Z,R,lat1,lon1,lat2,lon2,alt1,alt2,alt1opt, ... alt2opt,actualradius)` does the visibility calculation on a sphere with the specified radius. If omitted, the radius of the earth in meters is assumed. The altitudes, elevations and the radius should be in the same units. This calling form is most useful for computations on bodies other than the earth.

`vis = los2(Z,R,lat1,lon1,lat2,lon2,alt1,alt2,alt1opt, ... alt2opt,actualradius,effectiveradius)` assumes a larger radius for propagation of the line of sight. This can account for the curvature of the signal path due to refraction in the atmosphere. For example, radio propagation in the atmosphere is commonly treated as straight line propagation on a sphere with 4/3 the radius of the earth. In that case the last two arguments would be `R_e` and `4/3*R_e`, where `R_e` is the radius of the earth. Use `Inf` as the effective radius for flat earth visibility calculations. The altitudes, elevations and radii should be in the same units.

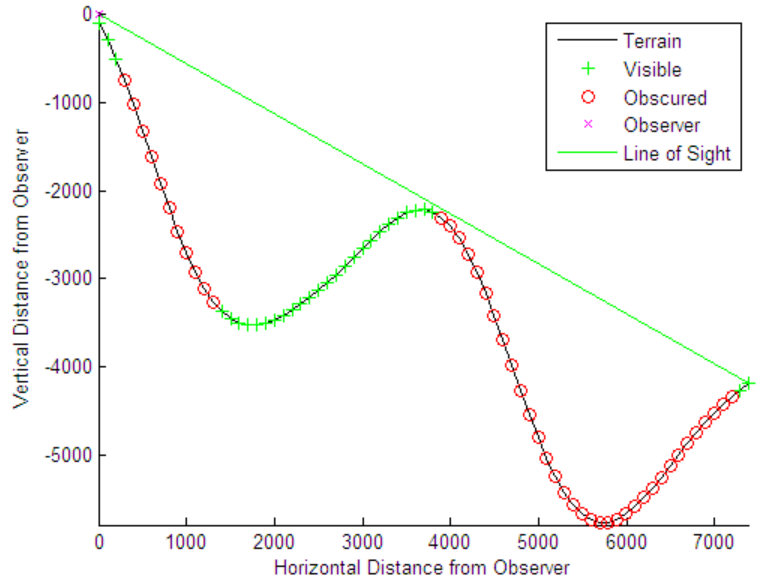
`[vis,visprofile,dist,H,lattrk,lontrk] = los2(...)`, for scalar inputs (`lat1`, `lon1`, etc.), returns vectors of points along the path between the two points. `visprofile` is a logical vector containing true (`logical(1)`) where the intermediate points are visible and false (`logical(0)`) otherwise. `dist` is the distance along the path (in meters or the units of the radius). `H` contains the terrain profile relative to the vertical datum along the path. `lattrk` and `lontrk` are the latitudes and longitudes of the points along the path. For vector inputs `los2` returns `visprofile`, `dist`, H, `lattrk`, and `lontrk` as cell arrays, with one cell per element of `lat1,lon1`, etc.

`los2(...)`, with no output arguments, displays the visibility profile between the two points in a new figure.

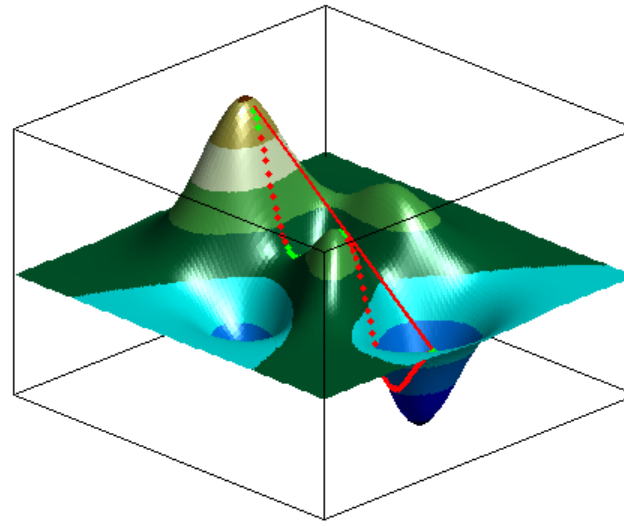
Examples

```
Z = 500*peaks(100);
refvec = [1000 0 0];
[lat1, lon1, lat2, lon2] = deal(-0.027, 0.05, -0.093, 0.042);
```

```
los2(Z,refvec,lat1,lon1,lat2,lon2,100);
```




```
figure;
axesm('globe','geoid',earthRadius('meters'))
meshm(Z, refvec, size(Z), Z); axis tight
camposm(-10,-10,1e6); camupm(0,0)
demcmap('inc', Z, 1000); shading interp; camlight
[vis,visprofile,dist,h,lattrk,lontrk] = ...
los2(Z,refvec,lat1,lon1,lat2,lon2,100);
plot3m(lattrk([1;end]),lontrk([1; end]),...
h([1; end])+[100; 0],'r','linewidth',2)
plotm(lattrk(~visprofile),lontrk(~visprofile),...
h(~visprofile),'r.','markersize',10)
plotm(lattrk(visprofile),lontrk(visprofile),...
h(visprofile),'g.','markersize',10)
```



See Also

viewshed | mapprofile

ltln2val

Purpose

Extract data grid values for specified locations

Syntax

```
val = ltln2val(Z, R, lat, lon)
val = ltln2val(Z, R, lat, lon, method)
```

Description

`val = ltln2val(Z, R, lat, lon)` interpolates a regular data grid `Z` with referencing vector `R` at the points specified by vectors of latitude and longitude, `lat` and `lon`. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to or from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Nearest-neighbor interpolation is used by default. NaN is returned for points outside the grid limits or for which `lat` or `lon` contain NaN. All angles are in units of degrees.

`val = ltln2val(Z, R, lat, lon, method)` accepts a `method` string to specify the type of interpolation: `'bilinear'` for linear interpolation, `'bicubic'` for cubic interpolation, or `'nearest'` for nearest neighbor interpolation.

Examples

Find the elevations in `topo` associated with three European cities—Milan, Bern, and Prague (`topo` elevations are in meters):

```
load topo
% The city locations, [Milan Bern Prague]
```

```
lats = [45.45; 46.95; 50.1];
longs = [9.2; 7.4; 14.45];
elevations = ltln2val(topo,topolegend,lats,longs)

elevations =
 313
 1660
 297
```

See Also

findm | imbedm

lv2ecef

Purpose

Convert local vertical to geocentric (ECEF) coordinates

Note `lv2ecef` will be removed in a future release. Use `enu2ecef` instead. In `enu2ecef`, the latitude and longitude of the local origin are in degrees by default, so the optional `angleUnit` input should be included, with the value `'radians'`.

Syntax

```
[x,y,z] = lv2ecef(xl,yl,zl,phi0,lambda0,h0,ellipsoid)
```

Description

`[x,y,z] = lv2ecef(xl,yl,zl,phi0,lambda0,h0,ellipsoid)` converts arrays `xl`, `yl`, and `zl` in the local vertical coordinate system to arrays `x`, `y`, and `z` in the geocentric coordinate system. The origin of the local vertical system is at geodetic latitude `phi0`, geodetic longitude `lambda0`, and ellipsoidal height `h0`. The arrays `xl`, `yl`, and `zl` may have any shape, as long as they are all the same size. They are measured in the same length units as the semimajor axis. `phi0` and `lambda0` are scalars measured in radians; `h0` is a scalar with the same length units as the semimajor axis; and `ellipsoid` is a `referenceEllipsoid` (`oblateSpheroid`) object, a `referenceSphere` object, or a vector of the form `[semimajor axis, eccentricity]`). The coordinates `x`, `y`, and `z` also have the same units as the semimajor axis.

Definitions

For a definition of the local vertical system, also known as East-North-Up (ENU), see the help for `ecef2lv`. For a definition of the geocentric system, also known as Earth-Centered, Earth-Fixed (ECEF), see the help for `geodetic2ecef`.

See Also

`ecef2enu`

Purpose

Semimajor axis of ellipse

Syntax

```
a = majaxis(semiminor,e)
a = majaxis(vec)
```

Description

`a = majaxis(semiminor,e)` computes the semimajor axis of an ellipse (or ellipsoid of revolution) given the semiminor axis and eccentricity. The input data can be scalar or matrices of equal dimensions.

`a = majaxis(vec)` assumes a 2 element vector (`vec`) is supplied, where `vec` = [`semiminor`, `e`].

See Also

`axes2ecc` | `flat2ecc` | `minaxis` | `n2ecc`

makeattribspec

Purpose

Attribute specification from geographic data structure

Syntax

```
attribspec = makeattribspec(S)
```

Description

`attribspec = makeattribspec(S)` analyzes a geographic data structure `S` and constructs an attribute specification suitable for use with `kmlwrite`. `kmlwrite`, given geostruct input, constructs an HTML table that consists of a label for the attribute in the first column and the string value of the attribute in the second column. You can modify `attribspec`, and then pass it to `kmlwrite` to exert control over which geostruct attribute fields are written to the HTML table and the format of the string conversion.

`attribspec` is a scalar MATLAB structure with two levels. The top level consists of a field for each attribute in S. Each of these fields, on the next level, contains a scalar structure with a fixed pair of fields:

`AttributeLabel`	A string that corresponds to the name of the attribute field in the geographic data structure. With `kmlwrite`, the string is used to label the attribute in the first column of the HTML table. The string may be modified prior to calling `kmlwrite`. You might modify an attribute label, for example, because you want to use spaces in your HTML table, but the attribute field names in `S` must be valid MATLAB variable names and cannot have spaces themselves.
`Format`	The `sprintf` format character string that converts the attribute value to a string.

Examples

1 Import a shapefile representing *tsunami* (tidal wave) events reported between 1950 and 2006 and tagged geographically by source location, and construct a default attribute specification (which includes all the shapefile attributes):

```
s = shaperead('tsunamis', 'UseGeoCoords', true);
```

```
attribspec = makeattribspec(s)
attribspec =

           Year: [1x1 struct]
          Month: [1x1 struct]
            Day: [1x1 struct]
           Hour: [1x1 struct]
         Minute: [1x1 struct]
         Second: [1x1 struct]
       Val_Code: [1x1 struct]
       Validity: [1x1 struct]
     Cause_Code: [1x1 struct]
          Cause: [1x1 struct]
         Eq_Mag: [1x1 struct]
        Country: [1x1 struct]
       Location: [1x1 struct]
     Max_Height: [1x1 struct]
       Iida_Mag: [1x1 struct]
      Intensity: [1x1 struct]
     Num_Deaths: [1x1 struct]
    Desc_Deaths: [1x1 struct]
```

2 Modify the attribute specification to

- Display just the attributes `Max_Height`, `Cause`, `Year`, `Location`, and `Country`
- Rename the `Max_Height` field to `Maximum Height`
- Display each attribute's label in bold type
- Set to zero the number of decimal places used to display `Year`
- Add "Meters" to the `Height` format, given independent knowledge of these units

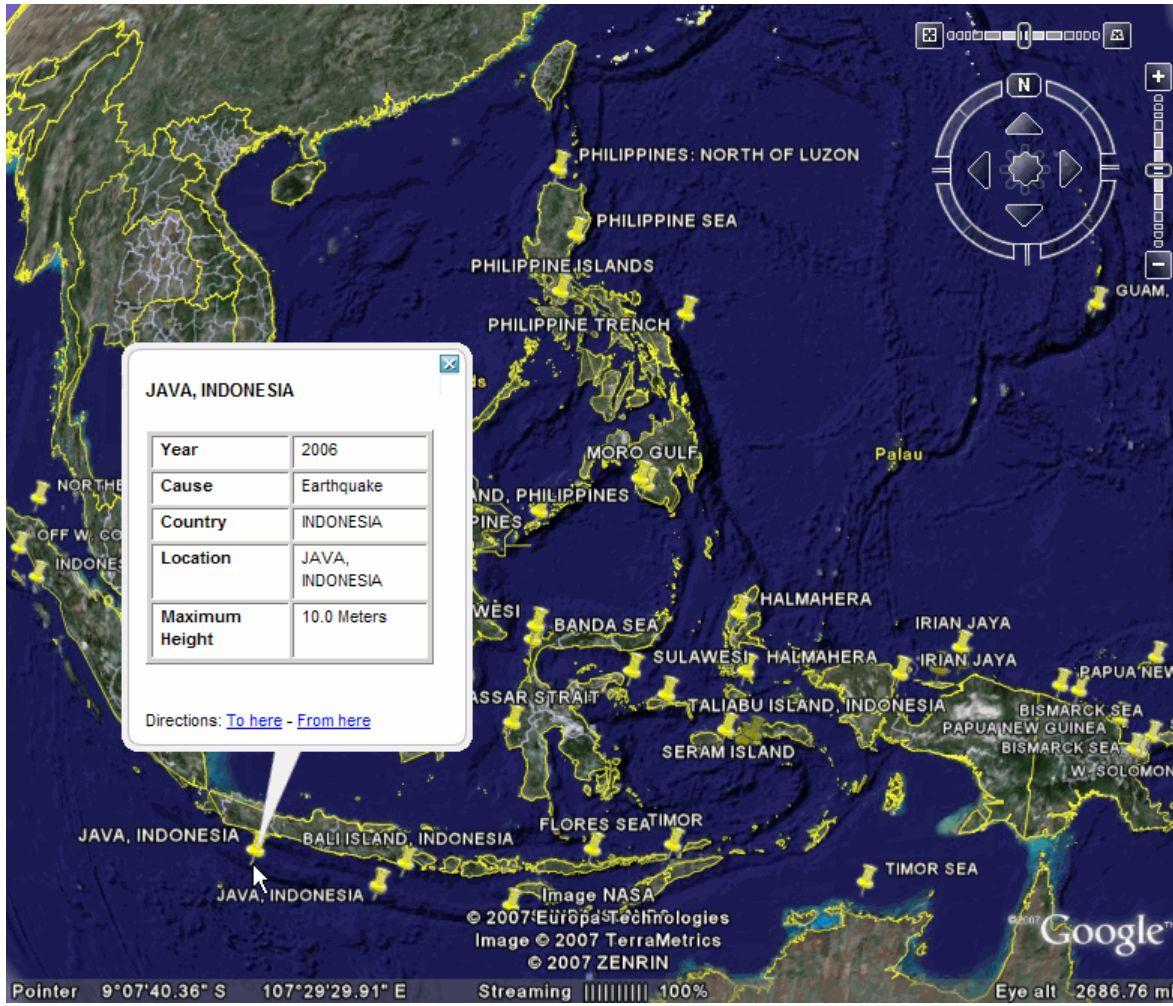
```
desiredAttributes = ...
       {'Max_Height', 'Cause', 'Year', 'Location', 'Country'};
allAttributes = fieldnames(attribspec);
attributes = setdiff(allAttributes, desiredAttributes);
```

```
attribspec = rmfield(attribspec, attributes);
attribspec.Max_Height.AttributeLabel = '<b>Maximum Height</b>';
attribspec.Max_Height.Format = '%.1f Meters';
attribspec.Cause.AttributeLabel = '<b>Cause</b>';
attribspec.Year.AttributeLabel = '<b>Year</b>';
attribspec.Year.Format = '%.0f';
attribspec.Location.AttributeLabel = '<b>Location</b>';
attribspec.Country.AttributeLabel = '<b>Country</b>';
```

3 Use the attribute specification to export the selected attributes and source locations to a KML file as a Description:

```
filename = 'tsunami.kml';
kmlwrite(filename, s, 'Description', attribspec, ...
   'Name', {s.Location})
```

A view of Southeast Asia produced by the Google Earth application shows the selected, formatted attributes displayed for a 2006 tsunami in Indonesia.



See also

`kmlwrite`, `makedbfspec`, `shapewrite`

makedbfspec

Purpose

DBF specification from geographic data structure

Syntax

```
dbfspec = makedbfspec(S)
```

Description

`dbfspec = makedbfspec(S)` analyzes a geographic data structure, `S`, and constructs a DBF specification suitable for use with `shapewrite`. You can modify `dbfspec`, then pass it to `shapewrite` to exert control over which geostruct attribute fields are written to the DBF component of the shapefile, the field-widths, and the precision used for numerical values.

`dbfspec` is a scalar MATLAB structure with two levels. The top level consists of a field for each attribute in `S`. Each of these fields, in turn, contains a scalar structure with a fixed set of four fields:

dbfspec field	Contents
`FieldName`	The field name to be used within the DBF file. This will be identical to the name of the corresponding attibute, but may modified prior to calling `shapewrite`. This might be necessary, for example, because you want to use spaces your DBF field names, but the attribute fieldnames in S must be valid MATLAB variable names and cannot have spaces themselves.
`FieldType`	The field type to be used in the file, either `'N'` (numeric) or `'C'` (character).
`FieldLength`	The number of bytes that each instance of the field will occupy in the file.
`FieldDecimalCount`	The number of digits to the right of the decimal place that are kept in a numeric field. Zero for integer-valued fields and character fields. The default value for noninteger numeric fields is 6.

Examples

Import a shapefile representing a small network of road segments, and construct a DBF specification.

```
s = shaperead('concord_roads')

s =
609x1 struct array with fields:
    Geometry
    BoundingBox
    X
    Y
    STREETNAME
    RT_NUMBER
    CLASS
    ADMIN_TYPE
    LENGTH

dbfspec = makedbfspec(s)

dbfspec =
    STREETNAME: [1x1 struct]
     RT_NUMBER: [1x1 struct]
         CLASS: [1x1 struct]
    ADMIN_TYPE: [1x1 struct]
        LENGTH: [1x1 struct]
```

Modify the DBF spec to (a) eliminate the `'ADMIN_TYPE'` attribute, (b) rename the `'STREETNAME'` field to `'Street Name'`, and (c) reduce the number of decimal places used to store road lengths.

```
dbfspec = rmfield(dbfspec,'ADMIN_TYPE')

dbfspec =
    STREETNAME: [1x1 struct]
     RT_NUMBER: [1x1 struct]
         CLASS: [1x1 struct]
        LENGTH: [1x1 struct]

dbfspec.STREETNAME.FieldName = 'Street Name';
dbfspec.LENGTH.FieldDecimalCount = 1;
```

Export the road network back to a modified shapefile. (Actually, only the DBF component will be different.)

```
shapewrite(s, 'concord_roads_modified', 'DbfSpec', dbfspec)
```

Verify the changes you made. Notice the appearance of `'Street Name'` in the field names reported by shapeinfo, the absence of the `'ADMIN_TYPE'` field, and the reduction in the precision of the road lengths.

```
info = shapeinfo('concord_roads_modified')
info =
       Filename: [3x28 char]
      ShapeType: 'PolyLine'
    BoundingBox: [2x2 double]
    NumFeatures: 609
     Attributes: [4x1 struct]

{info.Attributes.Name}

ans =
    'Street Name'    'RT_NUMBER'    'CLASS'    'LENGTH'

r = shaperead('concord_roads_modified')

r =
609x1 struct array with fields:
    Geometry
    BoundingBox
    X
    Y
    StreetName
    RT_NUMBER
    CLASS
    LENGTH

s(33).LENGTH
```

```
ans =
    3.492817400000000e+002

r(33).LENGTH

ans =
    3.493000000000000e+002
```

See also

shapeinfo, shapewrite

makemapped

Purpose

Convert ordinary graphics object to mapped object

Syntax

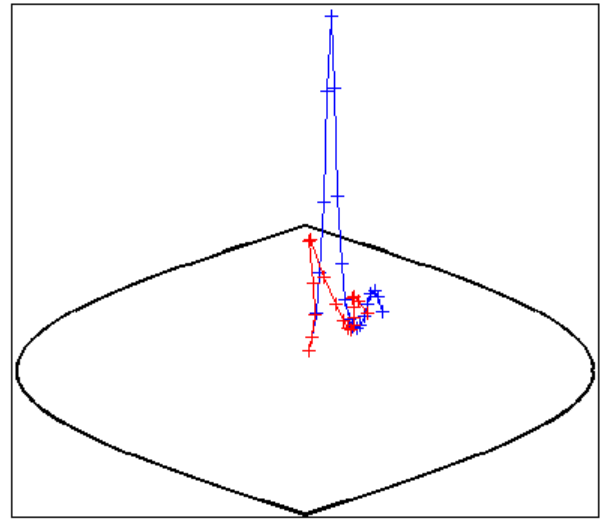
```
makemapped(h)
```

Description

`makemapped(h)` modifies the graphic object(s) associated with `h` such that upon subsequent modification of map axes properties, they are automatically reprojected appropriately. The object's coordinates are not changed by `makemapped`, but will change should you modify the map projection. `h` can be a handle, vector of handles, or any name string recognized by `handlem`. The objects are then considered to be geographic data. You should first trim objects extending outside the map frame to the map frame using `trimcart`.

Examples

```
axesm('miller','geoid',[25 0])
framem
plot(humps,'b+-')

h = plot(humps,'r+-');
trimcart(h)
makemapped(h)

setm(gca,'MapProjection','sinusoid')
```



Tips

Objects should first be trimmed to the map frame using `trimcart`. This avoids problems in taking inverse map projections with out-of-range data.

See Also

`trimcart` | `handlem` | `cart2grn`

makerefmat

Purpose

Construct affine spatial-referencing matrix

Syntax

```
R = makerefmat(x11, y11, dx, dy)
R = makerefmat(lon11, lat11, dlon, dlat)
R = makerefmat(param1, val1, param2, val2, ...)
```

Description

`R = makerefmat(x11, y11, dx, dy)`, with scalars `dx` and `dy`, constructs a referencing matrix that aligns image or data grid rows to map *x* and columns to map *y*. Scalars `x11` and `y11` specify the map location of the center of the first (1,1) pixel in the image or the first element of the data grid, so that

```
[x11 y11] = pix2map(R,1,1)
```

`dx` is the difference in *x* (or longitude) between pixels in successive columns, and `dy` is the difference in *y* (or latitude) between pixels in successive rows. More abstractly, `R` is defined such that

```
[x11 + (col-1) * dx, y11 + (row-1) * dy] = pix2map(R, row, col)
```

Pixels cover squares on the map when `abs(dx) = abs(dy)`. To achieve the most typical kind of alignment, where *x* increases from column to column and *y* decreases from row to row, make `dx` positive and `dy` negative. In order to specify such an alignment along with square pixels, make `dx` positive and make `dy` equal to `-dx`:

```
R = makerefmat(x11, y11, dx, -dx)
```

`R = makerefmat(x11, y11, dx, dy)`, with two-element vectors `dx` and `dy`, constructs the most general possible kind of referencing matrix, for which

```
[x11 + ([row col]-1) * dx(:), y11 + ([row col]-1) * dy(:)] ...

 = pix2map(R, row, col)
```

In this general case, each pixel can become a parallelogram on the map, with neither edge necessarily aligned to map *x* or *y*. The vector

`[dx(1) dy(1)]` is the difference in map location between a pixel in one row and its neighbor in the preceding row. Likewise, `[dx(2) dy(2)]` is the difference in map location between a pixel in one column and its neighbor in the preceding column.

To specify pixels that are rectangular or square (but possibly rotated), choose `dx` and `dy` such that `prod(dx) + prod(dy) = 0`. To specify square (but possibly rotated) pixels, choose `dx` and `dy` such that the 2-by-2 matrix `[dx(:) dy(:)]` is a scalar multiple of an orthogonal matrix (that is, its two eigenvalues are real, nonzero, and equal in absolute value). This amounts to either rotation, a mirror image, or a combination of both. Note that for scalars `dx` and `dy`,

```
R = makerefmat(x11, y11, [0 dx], [dy 0])
```

is equivalent to

```
R = makerefmat(x11, y11, dx, dy)
```

`R = makerefmat(lon11, lat11, dlon, dlat)`, with longitude preceding latitude, constructs a referencing matrix for use with geographic coordinates. In this case,

```
[lat11,lon11] = pix2latlon(R,1,1),
[lat11+(row-1)*dlat,lon11+(col-1)*dlon] = pix2latlon(R,row,col)
```

for scalar `dlat` and `dlon`, and

```
[lat11+[row col]-1)*dlat,lon11+([row col]-1)*dlon] = ...
pix2latlon(R, row,col)
```

for vector `dlat` and `dlon`. Images or data grids aligned with latitude and longitude might already have referencing vectors. In this case you can use function `refvec2mat` to convert to a referencing matrix.

`R = makerefmat(param1, val1, param2, val2, ...)` uses parameter name-value pairs to construct a referencing matrix for an image or raster grid that is referenced to and aligned with a geographic coordinate system. There can be no rotation or skew: each column must

fall along a meridian, and each row must fall along a parallel. Each parameter name must be specified exactly as shown, including case.

Parameter Name	Data Type	Value

`RasterSize`	Two-element size vector `[M N]`	The number of rows (`M`) and columns (`N`) of the raster or image to be used with the referencing matrix.
		
		With `'RasterSize'`, you may also provide a size vector having more than two elements. This enables usage such as:
		
		`R = makerefmat('RasterSize', ...`
		`  size(RGB), ...)`
		
		where `RGB` is `M-by-N-by-3`. However, in cases like this, only the first two elements of the size vector will actually be used. The higher (non-spatial) dimensions will be ignored. The default value is [1 1].

`Latlim`	Two-element row vector of the form: `[southern_limit, northern_limit]`, in units of degrees.	The limits in latitude of the geographic quadrangle bounding the georeferenced raster. The default value is [0 1].
`Lonlim`	Two-element row vector of the form: `[western_limit, eastern_limit]`, in units of degrees.	The limits in longitude of the geographic quadrangle bounding the georeferenced raster. The elements of the `'Lonlim'` vector must be ascending in value. In other words, the limits must be unwrapped. The default value is [0 1].

Parameter Name	Data Type	Value
`ColumnsStartFrom`	String	Indicates the column direction of the raster (south-to-north vs. north-to-south) in terms of the edge from which row indexing starts. The input string can have the value `'south'` or `'north'`, can be shortened, and is case-insensitive. In a typical terrain grid, row indexing starts at southern edge. In images, row indexing starts at northern edge. The default value is `'south'`.
`RowsStartFrom`	String	Indicates the row direction of the raster (west-to-east vs. east-to-west) in terms of the edge from which column indexing starts. The input string can have the value `'west'` or `'east'`, can be shortened, and is case-insensitive. Rows almost always run from west to east. The default value is `'west'`.

Definitions

Spatial Referencing Matrix

A spatial referencing matrix `R` ties the row and column subscripts of an image or regular data grid to 2-D map coordinates or to geographic coordinates (longitude and geodetic latitude). `R` is a 3-by-2 affine transformation matrix. `R` either transforms pixel subscripts (row, column) to/from map coordinates (`x`,`y`) according to

```
[x y] = [row col 1] * R
```

or transforms pixel subscripts to/from geographic coordinates according to

```
[lon lat] = [row col 1] * R
```

To construct a referencing matrix for use with geographic coordinates, use longitude in place of `X` and latitude in place of `Y`, as shown in the `R = makerefmat(X11, Y11, dx, dy)` syntax. This is one of the few places where longitude precedes latitude in a function call.

Examples

Create a referencing matrix for an image with square, four-meter pixels and with its upper left corner (in a map coordinate system) at $x = 207000$ meters, $y = 913000$ meters. The image follows the typical orientation: x increasing from column to column and y decreasing from row to row.

```
x11 = 207002;  % Two meters east of the upper left corner
y11 = 912998;  % Two meters south of the upper left corner
dx =  4;
dy = -4;
R = makerefmat(x11, y11, dx, dy)
```

Create a referencing matrix for a global geoid grid.

```
% Add array 'geoid' to the workspace:
load geoid

%'geoid' contains a model of the Earth's geoid sampled in
% one-degree-by-one-degree cells. Each column of 'geoid'
% contains geoid heights in meters for 180 cells starting
% at latitude -90 degrees and extending to +90 degrees, for
% a given longitude. Each row contains geoid heights for 360
% cells starting at longitude 0 and extending 360 degrees.
geoidR = makerefmat('RasterSize', size(geoid), ...
   'Latlim', [-90 90], 'Lonlim', [0 360])

% At its most extreme, the geoid reaches a minimum of slightly
% less than -100 meters. This minimum occurs in the Indian Ocean
% at approximately 4.5 degrees latitude, 78.5 degrees longitude.
% Check the geoid height at its most extreme by using latlon2pix
% with the referencing matrix.
[row, col] = latlon2pix(geoidR, 4.5, 78.5)
```

```
geoid(round(row),round(col))
```

See Also

`latlon2pix` | `map2pix` | `pix2latlon` | `pix2map` | `refvec2mat` | `worldfileread` | `worldfilewrite`

Tutorials

- Creating a Half-Resolution Georeferenced Image

How To

- "Understanding Raster Geodata"

makesymbolspec

Purpose

Construct vector layer symbolization specification

Syntax

```
symbolspec = makesymbolspec(geometry,rule1,rule2,...ruleN)
```

Description

`symbolspec = makesymbolspec(geometry,rule1,rule2,...ruleN)` constructs a symbol specification structure (`symbolspec`) for symbolizing a (vector) shape layer in the Map Viewer or when using `mapshow`. `geometry` is one of `'Point'`, `'Line'`, `'PolyLine'`, `'Polygon'`, or `'Patch'`. Rules, defined in detail below, specify the graphics properties for each feature of the layer. A rule can be a default rule that is applied to all features in the layer or it may limit the symbolization to only those features that have a particular value for a specified attribute. Features that do not match any rules are displayed using the default graphics properties.

To create a rule that applies to all features, a default rule, use the following syntax:

```
{'Default',Property1,Value1,Property2,Value2,...
           PropertyN,ValueN}
```

To create a rule that applies only to features that have a particular value or range of values for a specified attribute, use the following syntax:

```
{AttributeName,AttributeValue,
Property1,Value1,Property2,Value2,...,PropertyN,ValueN}
```

`AttributeValue` and `ValueN` can each be a two-element vector, `[low high]`, specifying a range. If `AttributeValue` is a range, `ValueN` might or might not be a range.

The following is a list of allowable values for `PropertyN`.

- Points or Multipoints: `'Marker'`, `'Color'`, `'MarkerEdgeColor'`, `'MarkerFaceColor'`, `'MarkerSize'`, and `'Visible'`
- Lines or PolyLines: `'Color'`, `'LineStyle'`, `'LineWidth'`, and `'Visible'`

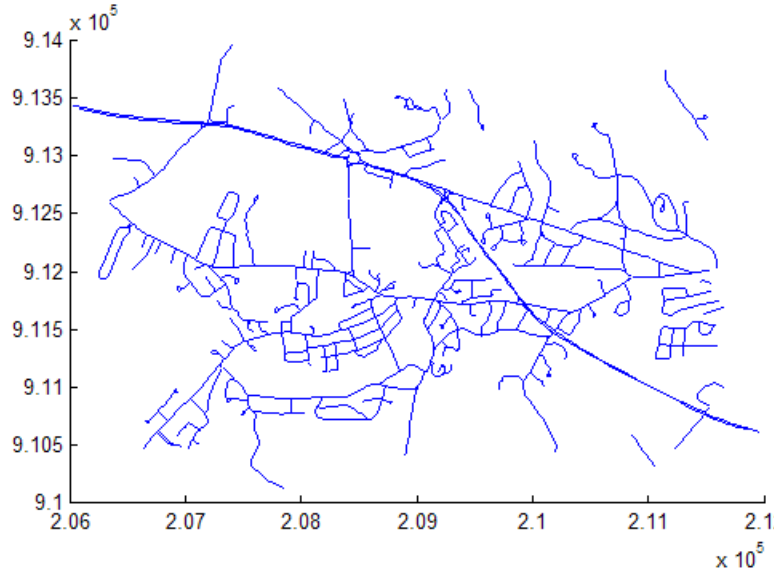
- Polygons: `'FaceColor'`, `'FaceAlpha'`, `'LineStyle'`, `'LineWidth'`, `'EdgeColor'`, `'EdgeAlpha'`, and `'Visible'`

Examples

The following examples import a shapefile containing road data and symbolize it in several ways using symbol specifications.

Example 1 — Default Color

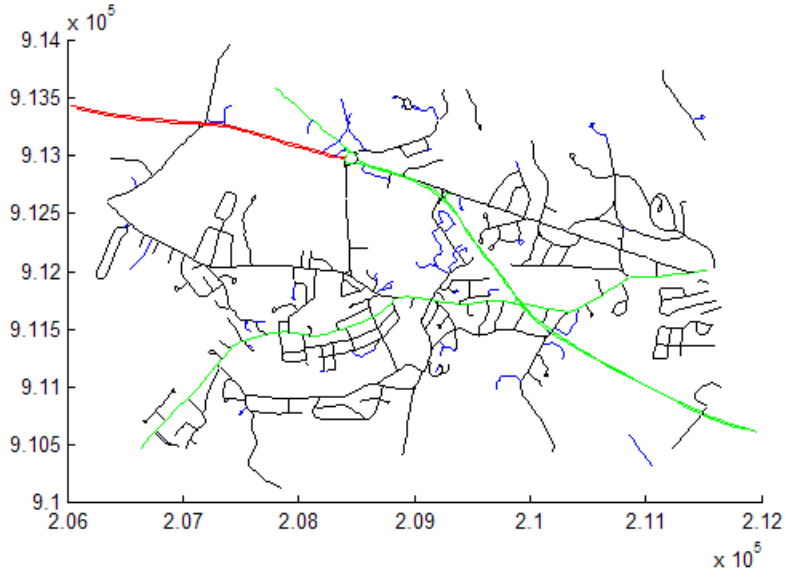
```
roads = shaperead('concord_roads.shp');
blueRoads = makesymbolspec('Line',{'Default','Color',[0 0 1]});
mapshow(roads,'SymbolSpec',blueRoads);
```



Example 2 — Discrete Attribute Based

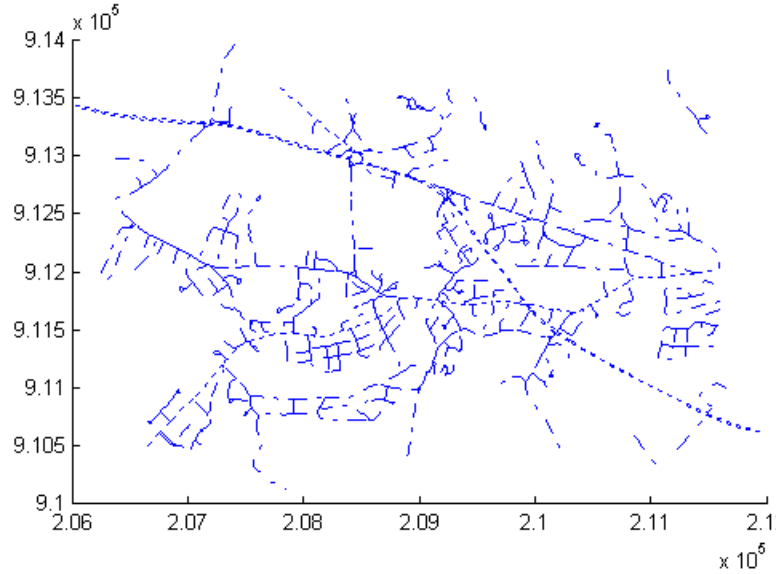
```
roads = shaperead('concord_roads.shp');
roadColors = ...
makesymbolspec('Line',{'CLASS',2,'Color','r'},...
                      {'CLASS',3,'Color','g'},...
                      {'CLASS',6,'Color','b'},...
```

```
                        {'Default','Color','k'});
mapshow(roads,'SymbolSpec',roadColors);
```



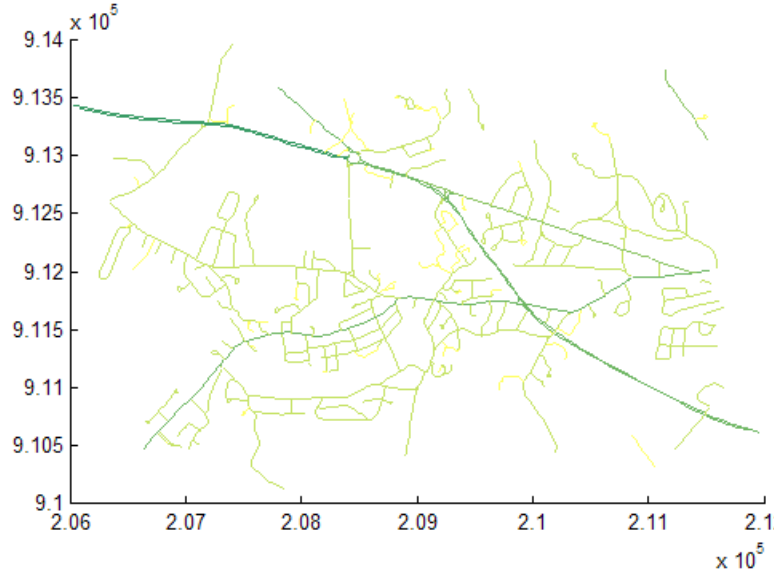
Example 3 — Using a Range of Attribute Values

```
roads = shaperead('concord_roads.shp');
lineStyle = makesymbolspec('Line',...
 {'CLASS',[1 3], 'LineStyle',':'},...
 {'CLASS',[4 6],'LineStyle','-.'});
mapshow(roads,'SymbolSpec',lineStyle);
```



Example 4 — Using a Range of Attribute Values and a Range of Property Values

```
roads = shaperead('concord_roads.shp');
colorRange = makesymbolspec('Line',...
                            {'CLASS',[1 6],'Color',summer(10)});
mapshow(roads,'SymbolSpec',colorRange);
```



See Also

`mapshow` | `geoshow` | `mapview`

Purpose

Convert map coordinates to pixel coordinates

Syntax

```
[row,col] = map2pix(R,x,y)
p = map2pix(R,x,y)
[...] = map2pix(R,s)
```

Description

`[row,col] = map2pix(R,x,y)` calculates pixel coordinates `row,col` from map coordinates `x,y`. `R` is either a 3-by-2 referencing matrix defining a 2-dimensional affine transformation from intrinsic pixel coordinates to map coordinates, or a `spatialref.MapRasterReference` object. `x` and `y` are vectors or arrays of matching size. The outputs `row` and `col` have the same size as `x` and `y`.

`p = map2pix(R,x,y)` combines `row` and `col` into a single array `p`. If `x` and `y` are column vectors of length `n`, then `p` is an `n`-by-2 matrix and each `p(k,:)` specifies the pixel coordinates of a single point. Otherwise, `p` has size `[size(row) 2]`, and `p(k1,k2,...,kn,:)` contains the pixel coordinates of a single point.

`[...] = map2pix(R,s)` combines `x` and `y` into a single array `s`. If `x` and `y` are column vectors of length `n`, the `s` should be an `n`-by-2 matrix such that each row `(s(k,:))` specifies the map coordinates of a single point. Otherwise, `s` should have size `[size(X) 2]`, and `s(k1,k2,...,kn,:)` should contain the map coordinates of a single point.

Examples

```
% Find the pixel coordinates for the spatial coordinates
% (207050, 912900)
R = worldfileread('concord_ortho_w.tfw');
[r,c] = map2pix(R, 207050, 912900);
```

See Also

`latlon2pix` | `makerefmat` | `pix2map` | `worldfileread`

mapbbox

Purpose

Compute bounding box of georeferenced image or data grid

Syntax

```
bbox = mapbbox(R, height, width)
bbox = mapbbox(R, sizea)
BBOX = mapbbox(info)
```

Description

`bbox = mapbbox(R, height, width)` computes the 2-by-2 bounding box of a georeferenced image or regular gridded data set. `R` is either a 3-by-2 referencing matrix defining a 2-dimensional affine transformation from intrinsic pixel coordinates to map coordinates, or a `spatialref.MapRasterReference` object. `height` and `width` are the image dimensions. `bbox` bounds the outer edges of the image in map coordinates:

```
[minX minY
 maxX maxY]
```

`bbox = mapbbox(R, sizea)` accepts `sizea = [height, width, ...]` instead of `height` and `width`.

`BBOX = mapbbox(info)` accepts a scalar struct array with the fields

`'RefMatrix'`	3-by-2 referencing matrix
`'Height'`	Scalar number
`'Width'`	Scalar number

See Also

`geotiffinfo` | `makerefmat` | `mapoutline` | `pixcenters` | `pix2map`

Purpose

Available Mapping Toolbox map projections

Syntax

```
list = maplist
[list,defproj] = maplist
```

Description

`list = maplist` returns a structure that lists all the available Mapping Toolbox map projections. The list structure is `list.Name`, `list.IdString`, `list.Classification`, `list.ClassCode`. This list structure is used by the functions `maps` and `axesmui` when processing map projection identifiers during operation of the toolbox functions.

`[list,defproj] = maplist` also returns the default projection's `IdString`.

`list.Name` defines the full name of the projection. This entry is used in the command-line table display and in the Projection Control Box.

`list.IdString` provides the name of the MATLAB function that computes the projection.

`list.Classification` defines the projection classification that is used in the command-line table display.

`list.ClassCode` defines the character string that is used to label the classes of projections in the Projection Control Box. The eight class codes are

- `Azim` — Azimuthal
- `Coni` — Conic
- `Cyln` — Cylindrical
- `Mazi` — Modified azimuthal
- `Pazi` — Pseudoazimuthal
- `Pcon` — Pseudoconic
- `Pcy` — Pseudocylindrical
- `Poly` — Polyconic

When map projections are added to the toolbox, the list structure needs to be extended. For example, if a new projection is added to the default list, then a new entry in the list structure would be

```
list.Name(61)           = 'My Projection'
list.IdString(61)       = 'newprojection';
list.Classification(61) = 'New Projection Type';
list.ClassCode(61)      = 'Code';
```

See Also

`maps | axesmui`

Purpose

Compute outline of georeferenced image or data grid

Syntax

```
[x,y] = mapoutline(R, height, width)
[x,y] = mapoutline(R, sizea)
[x,y] = mapoutline(info)
[x,y] = mapoutline(...,'close')
[lon,lat] = mapoutline(R,...)
outline = mapoutline(...)
```

Description

`[x,y] = mapoutline(R, height, width)` computes the outline of a georeferenced image or regular gridded data set in map coordinates. `R` is either a 3-by-2 referencing matrix defining a 2-dimensional affine transformation from intrinsic pixel coordinates to map coordinates, or a `spatialref.MapRasterReference` object. `height` and `width` are the image dimensions. `x` and `y` are 4-by-1 column vectors containing the map coordinates of the outer corners of the corner pixels, in the following order:

`(1,1), (height,1), (height, width), (1, width)`.

`[x,y] = mapoutline(R, sizea)` accepts `sizea = [height, width, ...]` instead of `height` and `width`.

`[x,y] = mapoutline(info)` accepts a scalar struct array with the fields

`'RefMatrix'`	3-by-2 referencing matrix
`'Height'`	Scalar number
`'Width'`	Scalar number

`[x,y] = mapoutline(...,'close')` returns `x` and `y` as 5-by-1 vectors, appending the coordinates of the first of the four corners to the end.

`[lon,lat] = mapoutline(R,...)`, where `R` georeferences pixels to longitude and latitude rather than map coordinates, returns the outline in geographic coordinates. Longitude must precede latitude in the output argument list.

`outline = mapoutline(...)` returns the corner coordinates in a 4-by-2 or 5-by-2 array.

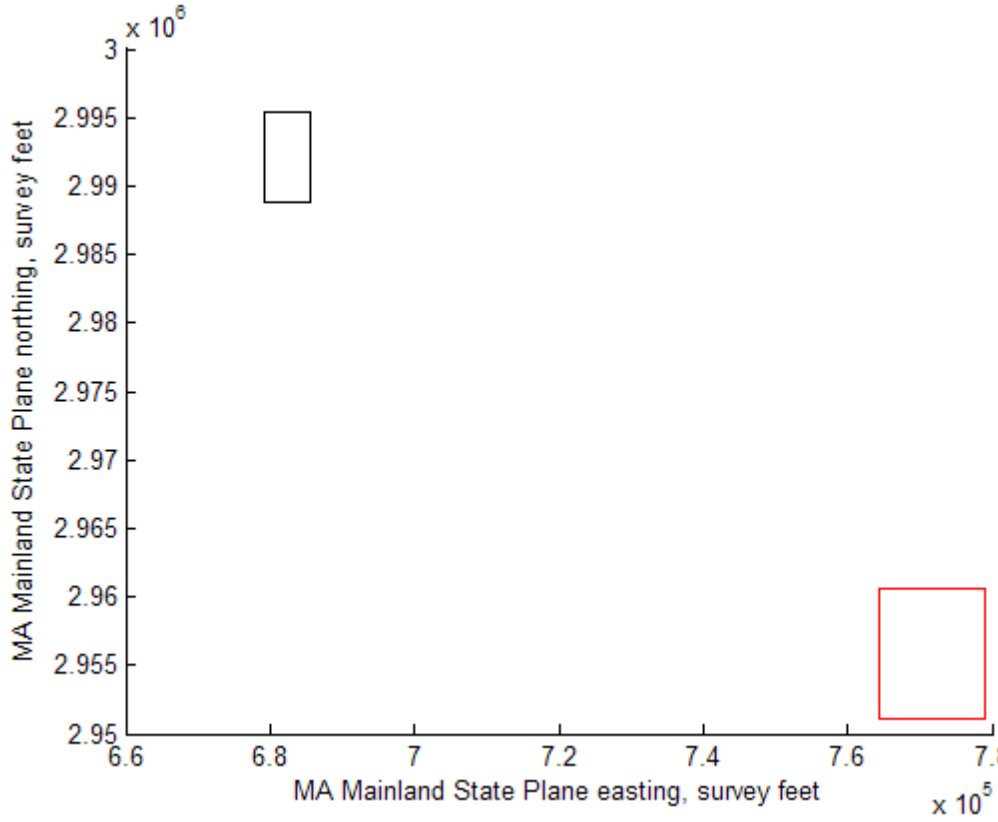
Examples

Draw a red outline delineating the Boston GeoTIFF image, which is referenced to the Massachusetts Mainland State Plane coordinate system with units of survey feet.

```
figure
info  = geotiffinfo('boston.tif');
[x,y] = mapoutline(info, 'close');
hold on
plot(x,y,'r')
xlabel('MA Mainland State Plane easting, survey feet')
ylabel('MA Mainland State Plane northing, survey feet')
```

Draw a black outline delineating a TIFF image of Concord, Massachusetts, while lies roughly 25 km north west of Boston. Convert world file units to survey feet from meters to be consistent with the Boston image.

```
info  = imfinfo('concord_ortho_w.tif');
R = worldfileread('concord_ortho_w.tfw');
R = R * unitsratio('sf','meter');
[x,y] = mapoutline(R, info.Height, info.Width, 'close');
plot(x,y,'k')
```



See Also `makerefmat` | `mapbbox` | `pixcenters` | `pix2map`

mappoint

Purpose

Planar point vector

Syntax

```
p = mappoint()
p = mappoint(x,y)
p = mappoint(x,y,Name,Value)
p = mappoint(structArray)
p = mappoint(x,y,structArray)
```

Description

A mappoint vector is a container object that holds planar point coordinates and attributes. The points are coupled, such that the size of the X and Y coordinate arrays are always equal and match the size of any dynamically added attribute arrays. Each entry of a coordinate pair and associated attributes, if any, represent a discrete element in the mappoint vector.

Construction

`p = mappoint()` constructs an empty mappoint vector, `p`, with these default property settings:

```
p =

 0x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: []
           Y: []
```

For an additional example, see “Constructor: mappoint()” on page 3-648.

`p = mappoint(x,y)` constructs a new mappoint vector and assigns the `X` and `Y` properties to the numeric array inputs, `lat` and `lon`. For an example, see“Constructor: mappoint(x,y)” on page 3-648 .

`p = mappoint(x,y,Name,Value)` constructs a mappoint vector from input arrays `x` and `y`, and then adds dynamic properties to the mappoint vector using the `Name`, `Value` argument pairs.

- If a specified name is `Metadata` and the corresponding `Value` is a scalar structure, then the value is copied to the `Metadata` property. Otherwise, an error is issued.

For an example, see "Constructor: mappoint(x,y,Name,Value)" on page 3-649.

`p = mappoint(structArray)` constructs a new `mappoint` vector from the fields of the structure, `structArray`. See for an example.

- If `structArray` is a scalar structure containing the field `Metadata` and the field value is a scalar structure, then the `Metadata` field is copied to the `Metadata` property. Otherwise, an error is issued if the `Metadata` field is not a structure, or ignored if `structArray` is not scalar.
- Other fields of `structArray` are assigned to `p` and become dynamic properties. Field values in `structArray` that are not numeric or strings or cell arrays of numeric or string values are ignored.

For an example, see "Constructor: mappoint(structArray)" on page 3-649.

`p = mappoint(x,y,structArray)` constructs a new `mappoint` vector and sets the `X` and `Y` properties equal to the numeric arrays, `x` and `y`, and sets dynamic properties from the field values of the structure, `structArray`.

- If `structArray` is a scalar structure containing the field `Metadata`, and the field value is a scalar structure, then it is copied to the `Metadata` property. Otherwise, an error is issued if the `Metadata` field is not a structure, or ignored if `structArray` is not scalar.

For an example, see "Constructor: mappoint(x,y,structArray)" on page 3-650.

Input Arguments

x

vector of latitude coordinates

Data Types
double | single

y

vector of longitude coordinates

Data Types
double | single

structArray

structure containing fields to be assigned as dynamic properties to `p`.

Name

Name of dynamic property

Data Types
char

Value

Property value associated with dynamic property `Name`. Values may be numeric, logical, char, or a cell array of strings.

Output Arguments

p

mappoint vector.

Properties

Each element in a mappoint vector is considered a feature. Feature properties contain one value (a scalar number or a string) for each element in the mappoint vector. The `Latitude` and `Longitude` coordinate properties are feature properties as there is one value for each feature.

`Geometry` and `Metadata` are collection properties. These properties contain only one value per class instance. The term *collection* is used to

distinguish these two properties from other feature properties which have values associated with each feature (element in a mappoint vector).

You can attach new dynamic feature properties to the object by using dot '.' notation. This is similar to adding dynamic fields to a structure. Dynamic feature properties apply to each individual feature in the mappoint vector. See "Multifeatures and Autosizing" on page 3-652for an example.

Geometry

String defining the type of geometry.

For `mappoint`, string is always `'point'`.

Attributes:

`Geometry`	`string`

Metadata

Metadata is a scalar structure containing information for the entire set of mappoint vector elements. You can add any data type to the structure.

Attributes:

`Metadata`	`Scalar struct`

X

Vector of planar X coordinates. The values can be either a row or column vector.

Attributes:

`X`	`single | double vector`

Y

Vector of planar Y coordinates. The values can be either a row or column vector.

Attributes:

`Y`	`single | double vector`

Dynamic properties

You can attach new properties to the object using dot `'.'` notation. The class type of the values for the dynamic properties must be either numeric, logical, char, or a cell array of strings.

Methods

append	Append features to mappoint vector
cat	Concatenate mappoint vectors
disp	Display mappoint vector
fieldnames	Dynamic properties of mappoint vector
isempty	True if `mappoint` vector is empty
isfield	Returns true if dynamic property exists
isprop	Returns true if property exists
length	Number of elements in mappoint vector
properties	properties of a mappoint vector
rmfield	Remove dynamic property from mappoint vector
rmprop	Remove properties from mappoint vector
size	Size of `mappoint` vector

struct	Convert mappoint vector to scalar structure
vertcat	Vertical concatenation for mappoint vectors

Copy Semantics

Value. To learn how value classes affect copy operations, see Copying Objects in the MATLAB Programming Fundamentals documentation.

Class Behaviors

- This example builds a default mappoint object and then dynamically adds a single feature.

  "Add a Dynamic Feature" on page 3-651

- mappoint vectors autoresize all properties lengths to ensure they are equal in size when a new dynamic property is added or an existing property appended or shortened.

  "Multifeatures and Autosizing" on page 3-652

- The class syntax containing the `Name-Value` pair allows features to be included during object construction.

  "Two Features at Construction" on page 3-656

- The data for the following example resides in a MAT file containing oceanic depths.

  "mappoint vector from a MAT file" on page 3-656

- This example also accesses data from a file and loads it into a structure array. Features are then added to the mappoint illustrating a number of behaviors.

  "Dynamic Features from Structure Arrays" on page 3-659

- In this example, a feature is added to the mappoint vector using linear indexing.

  "Append a Point by Indexing" on page 3-661

- Features can be sorted by using the indexing behavior of the mappoint class.

  "Sort Dynamic Properties" on page 3-663

- This example demonstrates that input arguments `x` and `y` can be either row or column vectors.

  "Row and Column Input Arguments" on page 3-665

Examples

Constructor: mappoint()

Construct a default mappoint vector.

Dynamically set the X and Y property values, and dynamically add Vertex property `Z`.

```
p = mappoint();
p.X = 1:3;
p.Y = 1:3;
p.Z = [10 10 10]
```

```
p =

 3x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [1 2 3]
           Y: [1 2 3]
           Z: [10 10 10]
```

Constructor: mappoint(x,y)

Construct a mappoint vector from x and y values.

```
x = [40 50 60];
y = [10, 11, 12];
p = mappoint(x, y)
```

```
p =

 3x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [40 50 60]
           Y: [10 11 12]
```

Constructor: mappoint(x,y,Name,Value)

Construct a mappoint vector from x, y, and temperature values.

```
x = 41:43;
y = 1:3;
temperature = 61:63;
p = mappoint(x, y, 'Temperature', temperature)
```

```
p =

 3x1 mappoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
              X: [41 42 43]
              Y: [1 2 3]
    Temperature: [61 62 63]
```

Constructor: mappoint(structArray)

Construct a mappoint vector from a structure array.

```
structArray = shaperead('boston_placenames')
p = mappoint(structArray)
```

```
structArray =

13x1 struct array with fields:
    Geometry
    X
    Y
    NAME
    FEATURE
    COORD


p =

 13x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [1x13 double]
           Y: [1x13 double]
        NAME: {1x13 cell}
     FEATURE: {1x13 cell}
       COORD: {1x13 cell
```

Constructor: mappoint(x,y,structArray)

Construct a mappoint vector from x and y numeric arrays and a structure array.

```
[structArray, A] = shaperead('boston_placenames');
x = [structArray.X];
y = [structArray.Y];
p = mappoint(x, y, A)

p =
```

```
 13x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [1x13 double]
           Y: [1x13 double]
        NAME: {1x13 cell}
     FEATURE: {1x13 cell}
       COORD: {1x13 cell}
```

Add a Dynamic Feature

Construct a mappoint vector for one feature.

```
x = 1;
y = 1;
p = mappoint(x, y)

p =

 1x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: 1
           Y: 1
```

Add a feature dynamic property with a string value.

```
p.FeatureName = 'My Feature'

p =

 1x1 mappoint vector with properties:
```

```
 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
              X: 1
              Y: 1
    FeatureName: 'My Feature'
```

Multifeatures and Autosizing

Construct a mappoint vector for two features. Add features dynamically.

```
x = [1 2];
y = [10 10];
p = mappoint(x, y)

p =

 2x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [1 2]
           Y: [10 10]
```

Add a feature dynamic property.

```
p.FeatureName = {'Feature 1', 'Feature 2'}

p =

 2x1 mappoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
```

```
             X: [1 2]
             Y: [10 10]
   FeatureName: {'Feature 1' 'Feature 2'}
```

Add a numeric feature dynamic property.

```
p.ID = [1 2]

p =

 2x1 mappoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
             X: [1 2]
             Y: [10 10]
   FeatureName: {'Feature 1' 'Feature 2'}
            ID: [1 2]
```

Add a third feature. All properties are autosized so that all vector lengths match.

```
p(3).X = 3
p(3).Y = 10

p =

 3x1 mappoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
             X: [1 2 3]
             Y: [10 10 10]
   FeatureName: {'Feature 1' 'Feature 2' ''}
```

```
            ID: [1 2 0]
```

Set the values for the ID feature dynamic property with more values than contained in X or Y. All properties are expanded to match in size.

```
p.ID = 1:4

p =

 4x1 mappoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
              X: [1 2 3 0]
              Y: [10 10 10 0]
    FeatureName: {'Feature 1' 'Feature 2' '' ''}
             ID: [1 2 3 4]
```

Set the values for the ID feature dynamic property with less values than contained in X or Y. The ID property values expand to match the length of X and Y.

```
p.ID = 1:2

p =

 4x1 mappoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
              X: [1 2 3 0]
              Y: [10 10 10 0]
    FeatureName: {'Feature 1' 'Feature 2' '' ''}
             ID: [1 2 0 0]
```

Set the values of either coordinate property (X or Y) with fewer values. All properties shrink in size to match the new length.

```
p.X = 1:2

p =

 2x1 mappoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
              X: [1 2]
              Y: [10 10]
    FeatureName: {'Feature 1' 'Feature 2'}
             ID: [1 2]
```

Remove the FeatureName (or ID) property by setting its value to [ ].

```
p.FeatureName = []

p =

 2x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [1 2]
           Y: [10 10]
          ID: [1 2]
```

Remove all dynamic properties and set the object to empty by setting a coordinate property value to [ ].

```
p.X = []
```

```
 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: []
           Y: []
```

Two Features at Construction

```
point = mappoint([42 44], [10, 11], 'Temperature', [63 65])

point =

 2x1 mappoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
              X: [42 44]
              Y: [10 11]
    Temperature: [63 65]
```

mappoint vector from a MAT file

Load data from file, add dynamic features and display data in figure windows.

Construct a mappoint vector to hold the coordinates from the seamount MAT-file. Add a dynamic feature property to indicate the Z coordinate. Add a dynamic feature property to indicate a binned level value and a color value for a given level. Include metadata information from the MAT-file.

```
seamount = load('seamount');
p = mappoint(seamount.x, seamount.y, 'Z', seamount.z);
```

Create a level list to use to bin the z values and create a list of color values for each level.

```
levels = [unique(floor(seamount.z/1000)) * 1000; 0];
colors = {'red', 'green', 'blue', 'cyan', 'black'};
```

Add a MinLevel and MaxLevel feature property to indicate the lowest and highest binned level.

```
for k = 1:length(levels) - 1
   index = levels(k) <= p.Z & p.Z < levels(k+1);
   p(index).MinLevel = levels(k);
   p(index).MaxLevel = levels(k+1) - 1;
   p(index).Color = colors{k};
end
```

Add metadata information. `Metadata` is a scalar structure containing information for the entire set of properties. Any type of data may be added to the structure.

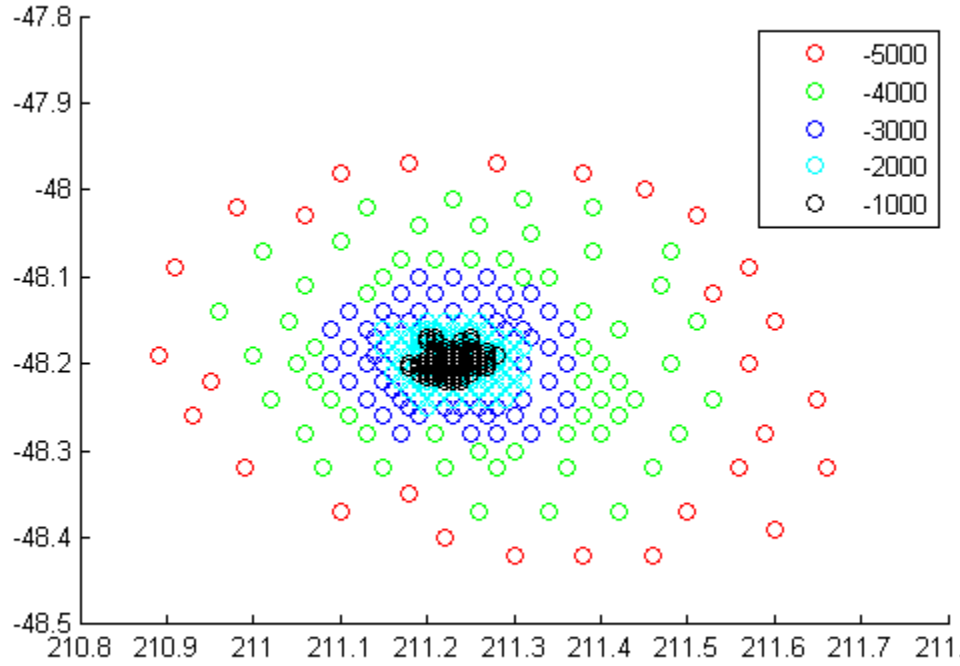
```
p.Metadata.Caption = seamount.caption;
p.Metadata
```

```
ans =

    Caption: [1x229 char]
```

Display the point data as a 2-D plot.

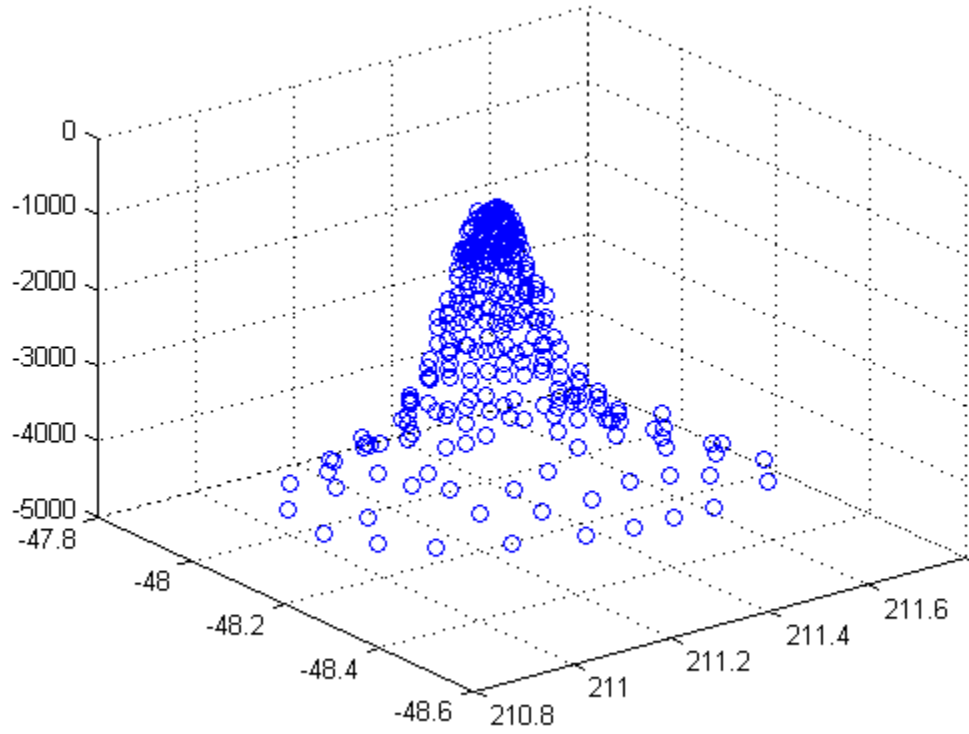
```
figure
minLevels = unique(p.MinLevel);
for k=1:length(minLevels)
  index = p.MinLevel == minLevels(k);
  mapshow(p(index).X, p(index).Y, ...
   'MarkerEdgeColor', p(find(index,1)).Color, ...
   'Marker', 'o', ...
   'DisplayType', 'point')
end
```

```
legend(num2str(minLevels'))
```



Display the point data as a 3-D scatter plot.

```
figure
scatter3(p.X, p.Y, p.Z)
```



Dynamic Features from Structure Arrays

Assign dynamic features to mappoint vector from a structure array.

```
structArray = shaperead('boston_placenames');
p = mappoint();
p.X = [structArray.X];
p.Y = [structArray.Y];
p.Name = {structArray.NAME}

p =
```

```
 13x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
              X: [1x13 double]
              Y: [1x13 double]
           Name: {1x13 cell}
```

Construct a mappoint vector from a structure array using the constructor syntax.

```
filename = 'boston_placenames.shp';
structArray = shaperead(filename);
p = mappoint(structArray)
```

```
p =

 13x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
              X: [1x13 double]
              Y: [1x13 double]
           NAME: {1x13 cell}
        FEATURE: {1x13 cell}
          COORD: {1x13 cell}
```

Add a Filename field to the Metadata structure. Display the first five points and the Metadata structure.

```
p.Metadata.Filename = filename;
p(1:5)
p.Metadata
```

```
ans =

 5x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [2.3403e+05 2.3357e+05 2.3574e+05 2.3627e+05 2.3574e+05]
           Y: [900038 9.0019e+05 9.0113e+05 9.0097e+05 9.0036e+05]
        NAME: {1x5 cell}
     FEATURE: {'PPL-SUBDVSN' ' MARSH' ' HILL' ' PPL' ' PENINSULA'}
       COORD: {1x5 cell}

ans =

    Filename: 'boston_placenames.shp'
```

Append a Point by Indexing

Append Paderborn Germany to the vector of world cities.

```
p = mappoint(shaperead('worldcities.shp'));
x = 51.715254;
y = 8.75213;
p = append(p, x, y, 'Name', 'Paderborn');
p(end)

ans =

 1x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: 51.7153
           Y: 8.7521
```

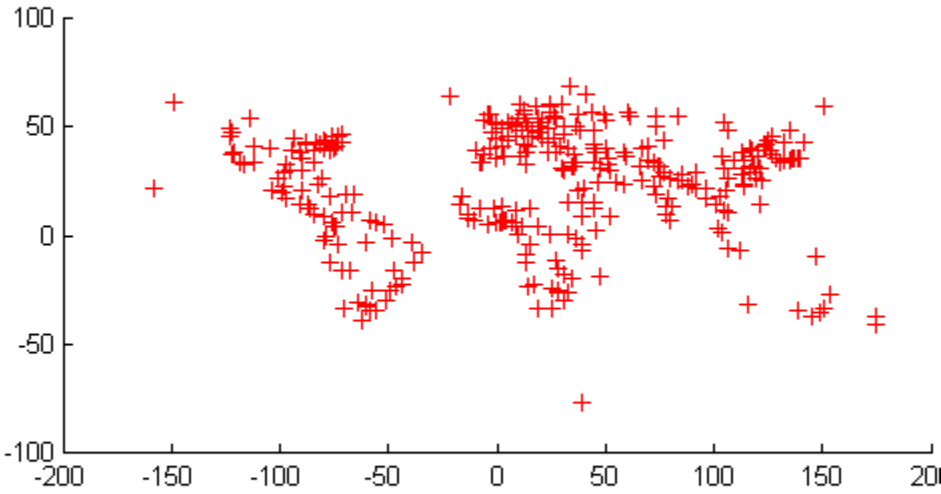
```
        Name: 'Paderborn'
```

You can also add a point to the end of the vector using linear indexing. Add Arlington, Virginia to the end of the vector.

```
p(end+1).X = 38.880043;
p(end).Y = -77.196676;
p(end).Name = 'Arlington';
p(end-1:end)

ans =

 2x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [51.7153 38.8800]
           Y: [8.7521 -77.1967]
        Name: {'Paderborn' 'Arlington'}
```

Plot the Points

```
figure
mapshow(p.X, p.Y, 'DisplayType', 'point')
```



Sort Dynamic Properties

Construct a mappoint vector and sort the dynamic properties.

```
p = mappoint(shaperead('tsunamis'));
p = p(:, sort(fieldnames(p)))
```

```
p =

 162x1 mappoint vector with properties:
```

```
 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
              X: [1x162 double]
              Y: [1x162 double]
          Cause: {1x162 cell}
     Cause_Code: [1x162 double]
        Country: {1x162 cell}
            Day: [1x162 double]
    Desc_Deaths: [1x162 double]
         Eq_Mag: [1x162 double]
           Hour: [1x162 double]
       Iida_Mag: [1x162 double]
      Intensity: [1x162 double]
       Location: {1x162 cell}
     Max_Height: [1x162 double]
         Minute: [1x162 double]
          Month: [1x162 double]
     Num_Deaths: [1x162 double]
         Second: [1x162 double]
       Val_Code: [1x162 double]
       Validity: {1x162 cell}
           Year: [1x162 double]
```

Modify the mappoint vector to contain only the dynamic properties, 'Year', 'Month', 'Day', 'Hour', 'Minute'.

```
p = p(:, {'Year', 'Month', 'Day', 'Hour', 'Minute'})
```

```
p =

 162x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
```

```
 Feature properties:
           X: [1x162 double]
           Y: [1x162 double]
        Year: [1x162 double]
       Month: [1x162 double]
         Day: [1x162 double]
        Hour: [1x162 double]
      Minute: [1x162 double]
```

Display the first 5 elements.

```
p(1:5)

ans =

 5x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [128.3000 -156 157.9500 143.8500 -155]
           Y: [-3.8000 19.5000 -9.0200 42.1500 19.1000]
        Year: [1950 1951 1951 1952 1952]
       Month: [10 8 12 3 3]
         Day: [8 21 22 4 17]
        Hour: [3 10 NaN 1 3]
      Minute: [23 57 NaN 22 58]
```

Row and Column Input Arguments

Input argument x and y values can be either Nx2 or 2xM arrays.

If you typically store x and y coordinate values in a N-by-2 or 2-by-M array, you can assign a mappoint object to these numeric values. If the values are stored in a N-by-2 array, then the X property values are assigned to the first column and the Y property values are assigned to the second column.

```
x = 1:10;
y = 21:30;
pts = [x' y'];
p = mappoint;
p(1:length(pts)) = pts

p =

 10x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [1 2 3 4 5 6 7 8 9 10]
           Y: [21 22 23 24 25 26 27 28 29 30]
```

If the values are stored in a 2-by-M array, then the X property values are assigned to the first row and the Y property values are assigned to the second row. pts = [x; y];

```
pts = [x; y];
p(1:length(pts)) = pts

p =

 10x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [1 2 3 4 5 6 7 8 9 10]
           Y: [21 22 23 24 25 26 27 28 29 30]
```

See Also

gpxread | shaperead | mappoint | geoshape | mapshape

Purpose

Append features to mappoint vector

Syntax

```
p = append(p,lat,lon)
p = append(p,lat,lon,Name,Value)
```

Description

`p = append(p,lat,lon)` appends the latitude values in the numeric array, `lat` to the `X` property of the mappoint vector, `p`, and the longitude values in the numeric array, `lon`, to the `Y` property of `p`.

`p = append(p,lat,lon,Name,Value)` appends `lat` and `lon` values to the mappoint vector. The method adds dynamic properties to the object using `Name` for the names of the dynamic properties, and then assign `Value` to them.

Input Arguments

p

mappoint vector.

x

Numeric vector of `X` values.

y

Numeric vector of `Y` values.

Name-Value pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

Name,Value

parameter Name-Value pairs of the dynamic properties that are to be added to the mappoint vector, `p`.

Output Arguments

p

Modified mappoint vector with additional entries in `X` and `Y` fields along with any new fields for dynamic properties that you added.

Examples

Append Values to Fields in a mappoint Vector

Append values to existing fields of a mappoint vector.

```
p = mappoint(42,-110, 'Temperature', 65);
p = append(p, 42.1, -110.4, 'Temperature', 65.5)

p =

 2x1 mappoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
              X: [42 42.1000]
              Y: [-110 -110.4000]
    Temperature: [65 65.5000]
```

Append Dynamic Property to a geopoint Vector

Append dynamic property, `'Pressure'`, to a mappoint vector.

```
p = mappoint(42,-110, 'Temperature', 65);
p = append(p, 42.2, -110.5, 'Temperature', 65.6, 'Pressure', 100.0)

p =

 2x1 mappoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
```

```
                X: [42 42.2000]
                Y: [-110 -110.5000]
      Temperature: [65 65.6000]
         Pressure: [0 100]
```

See Also

mappoint.vertcat |

mappoint.cat

Purpose

Concatenate mappoint vectors

Syntax

```
p= cat(dim,p1, p2, ...)
```

Description

`p= cat(dim,p1, p2, ...)` concatenates the mappoint vectors `p1`,`p2` and so on along dimensions `dim`. `dim` must be `1`.

Input Arguments

`p1, p2, ...`

mappoint vectors to be concatenated.

Output Arguments

`p`

Concatenated mappoint vector.

Examples

Concatenate two mappoint vectors

Create two mappoint vectors and concatenate them to a single vector.

```
pt1 = mappoint(42,-110, 'Temperature', 65);
pt2 = mappoint(42.2, -110.5, 'Temperature', 65.6);
p = cat(1,pt1,pt2)
```

```
p =

 2x1 mappoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
              X: [42 42.2000]
              Y: [-110 -110.5000]
    Temperature: [65 65.6000]
```

See Also

`mappoint.vertcat` |

Purpose

Display mappoint vector

Syntax

```
disp(p)
```

Description

`disp(p)` prints the size of the mappoint vector, `p`, and its properties and dynamic properties, if they exist. If the command window is large enough, the values of the properties are also shown, otherwise only their size is shown. You can control the display of the numerical values by using the format command.

Input Arguments

`p`

mappoint vector.

Examples

Display a mappoint vector

Display a mappoint vector.

```
p = mappoint(shaperead('worldcities'));
disp(p)
disp(p(1:2))
```

```
  318x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [1x318 double]
           Y: [1x318 double]
        Name: {1x318 cell}

 2x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
```

```
     X: [-3.9509 54.7589]
     Y: [5.2985 24.6525]
  Name: {'Abidjan' 'Abu Dhabi'}
```

See Also

formatmappoint |

Purpose

Dynamic properties of mappoint vector

Syntax

```
names = fieldnames(p)
```

Description

`names = fieldnames(p)` returns the names of the dynamic properties of the mappoint vector, `p`.

Input Arguments

p

mappoint vector for which the properties are to be queried.

Output Arguments

names

Names of the dynamic properties in the mappoint vector `p`

Examples

Find dynamic properties

Return the dynamic properties of a mappoint vector

```
p = mappoint(shaperead('worldcities'))
fieldnames(p)
```

```
p =

 318x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [1x318 double]
           Y: [1x318 double]
        Name: {1x318 cell}

ans =

    'Name'
```

See Also `mappoint.properties` |

Purpose

True if `mappoint` vector is empty

Syntax

```
tf = isempty(p)
```

Description

`tf = isempty(p)` returns true if the mappoint vector, `p`, is empty and false otherwise.

Input Arguments

`p`

mappoint vector.

Examples

Check if a mappoint vector is empty

Check if the mappoint vector is empty.

```
p = mappoint();
isempty(p)
```

```
ans =

     1
```

See Also

`mappoint.end` |

mappoint.isfield

Purpose

Returns true if dynamic property exists

Syntax

```
tf = isfield(p,name)
tf = isfield(p,names)
```

Description

`tf = isfield(p,name)` returns true if the value specified by the string `name` is a dynamic property of the mappoint vector, `p`.

`tf = isfield(p,names)` return true for each element of the cell array, `names`, that is a dynamic property of `p`. `tf` is a logical array of the same size as `names`.

Input Arguments

p

mappoint vector.

name

Name of the dynamic property.

names

Cell array of names of dynamic properties.

Output Arguments

tf

`Boolean`. 1 if `p` contains the specified fields or 0 otherwise.

Examples

Check for fieldname

Check if a field is present in a mappoint vector.

```
p = mappoint(-33.961, 18.484, 'Name', 'Cape Town');
isfield(p, 'X')
isfield(p, 'Name')

ans =

     0
```

```
ans =

     1
```

See Also

mappoint.isprop | mappoint.fieldnames |

mappoint.isprop

Purpose

Returns true if property exists

Syntax

```
tf = isprop(p,name)
tf = isprop(p,names)
```

Description

`tf = isprop(p,name)` returns true if the value specified by the string, `name` is a property of the mappoint vector, `p`.

`tf = isprop(p,names)` returns true for each element of the cell array of strings, `names`, that is a property of `p`. `tf` is a logical array the same size as `names`.

Input Arguments

p

mappoint vector.

name

String specifying the property of the mappoint vector, `p`.

names

Cell array of strings specifying the property of the mappoint vector, `p`.

Output Arguments

tf

Boolean. 1 if the property exists with `p` ,0 otherwise.

Examples

Check if property exists

This example shows how to check if a string is a property of a mappoint vector.

```
p = mappoint(-33.961, 18.484, 'Name', 'Cape Town');
isprop(p, 'X')
isprop(p, 'Name')
```

```
ans =

     1
```

```
ans =

     1
```

See Also

mappoint.isfield | mappoint.properties |

mappoint.length

Purpose

Number of elements in mappoint vector

Syntax

```
N = length(p)
```

Description

`N = length(p)` returns the number of elements contained in the mappoint vector, `p`. The result is equivalent to `size(p,1)`.

Input Arguments

`p`

mappoint vector.

Output Arguments

`N`

Length of the mappoint vector, p.

Examples

Find the length of the mappoint vector.

```
coast = load('coast');
p = mappoint(coast.lat, coast.long);
length(p)
length(coast.lat)
```

```
ans =

        9865


ans =

        9865
```

See Also

`mappoint.size` |

Purpose

properties of a mappoint vector

Syntax

```
prop = properties(p)
properties(p)
```

Description

`prop = properties(p)` returns a cell of the property names of the mappoint vector, `p`.

`properties(p)` displays the names of the properties of `p`.

Input Arguments

p

mappoint vector.

Output Arguments

prop

Cell variable consisting of property names of the mappoint vector, `p`.

Examples

properties of a mappoint vector

Query for properties of a mappoint vector.

```
p = mappoint(shaperead('tsunamis'));
properties(p)
```

```
Properties for class mappoint:

    Geometry
    Metadata
    X
    Y
    Year
    Month
    Day
    Hour
    Minute
    Second
```

```
Val_Code
Validity
Cause_Code
Cause
Eq_Mag
Country
Location
Max_Height
Iida_Mag
Intensity
Num_Deaths
Desc_Deaths
```

See Also `mappoint.fieldnames` |

Purpose

Remove dynamic property from mappoint vector

Syntax

```
p = rmfield(p, fieldname)
p = rmfield(p, fields)
```

Description

`p = rmfield(p, fieldname)` removes the field specified by the string, `fieldname` , from the mappoint vector, `p`.

`p = rmfield(p, fields)` removes all the fields specified by the cell array, `fields`.

Note `rmfield` cannot remove `X`, `Y` and `Metadata` fields and the string specified is case sensitive.

Input Arguments

p

mappoint vector.

fieldname

Exact string representing the name of the property.

fields

Cell array of strings specifying the names of the properties.

Output Arguments

p

Updated mappoint vector with the field(s) removed.

Examples

Remove fields from a mappoint vector

Remove fields from a mappoint vector.

```
p = mappoint(shaperead('tsunamis'));
p2 = rmfield(p, 'Geometry')
```

```
p2 =
```

```
162x1 mappoint vector with properties:

Collection properties:
      Geometry: 'point'
      Metadata: [1x1 struct]
Feature properties:
             X: [1x162 double]
             Y: [1x162 double]
          Year: [1x162 double]
         Month: [1x162 double]
           Day: [1x162 double]
          Hour: [1x162 double]
        Minute: [1x162 double]
        Second: [1x162 double]
      Val_Code: [1x162 double]
      Validity: {1x162 cell}
    Cause_Code: [1x162 double]
         Cause: {1x162 cell}
        Eq_Mag: [1x162 double]
       Country: {1x162 cell}
      Location: {1x162 cell}
    Max_Height: [1x162 double]
      Iida_Mag: [1x162 double]
     Intensity: [1x162 double]
    Num_Deaths: [1x162 double]
   Desc_Deaths: [1x162 double]
```

See Also

mappoint.fieldnames | mappoint.rmprop |

Purpose

Remove properties from mappoint vector

Syntax

```
pF = rmprop(p,propname)
pF = rmprop(p,propnames)
```

Description

`pF = rmprop(p,propname)` removes the property specified by the string, `propname` from the mappoint vector, `p`.

`pF = rmprop(p,propnames)` removes all the properties specified in the cell array, `propnames`, from the mappoint vector, `p`. If `propnames` contains a coordinate property an error is issued.

Note `rmprop` cannot remove `X`, `Y` and `Metadata` fields and the string specified is case sensitive.

Input Arguments

`p`

mappoint vector.

Output Arguments

`pF`

Modified mappoint vector with the specified property(s) removed.

Examples

Remove a property of a mappoint vector

Remove a property from a mappoint vector.

```
p = mappoint(shaperead('tsunamis'));
p2 = rmprop(p, 'Validity')
```

```
p2 =

 162x1 mappoint vector with properties:

 Collection properties:
       Geometry: 'point'
```

```
      Metadata: [1x1 struct]
Feature properties:
             X: [1x162 double]
             Y: [1x162 double]
          Year: [1x162 double]
         Month: [1x162 double]
           Day: [1x162 double]
          Hour: [1x162 double]
        Minute: [1x162 double]
        Second: [1x162 double]
      Val_Code: [1x162 double]
    Cause_Code: [1x162 double]
         Cause: {1x162 cell}
        Eq_Mag: [1x162 double]
       Country: {1x162 cell}
      Location: {1x162 cell}
    Max_Height: [1x162 double]
      Iida_Mag: [1x162 double]
     Intensity: [1x162 double]
    Num_Deaths: [1x162 double]
   Desc_Deaths: [1x162 double]
```

See Also `mappoint.fieldnames` |

Purpose

Size of `mappoint` vector

Syntax

```
SZ = size(p)
SZ = size(p,1)
SZ = size(p, n)
[m,k] = size(p)
```

Description

`SZ = size(p)` returns the vector `[length(p), 1]`.

`SZ = size(p,1)` returns the length of `p`.

`SZ = size(p, n)` returns `1` for `n >= 2`.

`[m,k] = size(p)` returns `length(p)` for `m` and `1` for `k`.

Input Arguments

`p`

mappoint vector.

`n`

Number of the dimension at which size of `p` is required.

Output Arguments

`SZ`

Vector of the form `[length(p), 1]`.

`m`

Length of `p`.

`k`

Length of second dimension of `p`. `k` is always `1`.

Examples

Size of a mappoint vector

Find the size of a mappoint vector.

```
coast = load('coast');
p = mappoint(coast.lat, coast.long);
size(p)
```

```
ans =

        9865           1
```

The second dimension is always 1.

See Also

`mappoint.length` | `size`

Purpose

Convert mappoint vector to scalar structure

Syntax

```
S = struct(p)
```

Description

`S = struct(p)` converts the mappoint vector, `p`, to a scalar structure, `S`.

Input Arguments

`p`

mappoint vector.

Output Arguments

`S`

Scalar structure of the mappoint vector `p`.

Examples

Converting a mappoint vector into struct

This example shows how to convert a mappoint vector to `struct`.

```
S = shaperead('worldcities');
p = mappoint(S)
S2 = struct(p)
class(S2)
```

```
p =

 318x1 mappoint vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Feature properties:
           X: [1x318 double]
           Y: [1x318 double]
        Name: {1x318 cell}


S2 =
```

```
    Geometry: 'point'
    Metadata: [1x1 struct]
           X: [1x318 double]
           Y: [1x318 double]
        Name: {1x318 cell}


ans =

struct
```

See Also mappoint.properties |

Purpose

Vertical concatenation for mappoint vectors

Syntax

```
p = vertcat(p1,p2, ...)
```

Description

`p = vertcat(p1,p2, ...)` vertically concatenates the mappoint vector, `p1, p2,` and so on. If the class type of any property is a cell array, then the resultant field in the output `p` will also be a cell array.

Input Arguments

`p1, p2, ...`

mappoint vectors that need to be concatenated.

Output Arguments

`p`

Concatenated mappoint vector.

Examples

Concatenate mappoint vectors

Concatenate two mappoint vectors.

```
pt1 = mappoint(42,   -110,   'Temperature', 65,   'Name', 'point1');
pt2 = mappoint(42.1, -110.4, 'Temperature', 65.5, 'Name', 'point2');
pts = vertcat(pt1, pt2)

pts =

 2x1 mappoint vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Feature properties:
              X: [42 42.1000]
              Y: [-110 -110.4000]
    Temperature: [65 65.5000]
           Name: {'point1' 'point2'}
```

See Also

`mappoint.cat` |

mapprofile

Purpose

Interpolate between waypoints on regular data grid

Syntax

```
[zi,ri,lat,lon] = mapprofile
[zi,ri,lat,lon] = mapprofile(Z,R,lat,lon)
[zi,ri,lat,lon] = mapprofile(Z,R,lat,lon,units)
[zi,ri,lat,lon] = mapprofile(Z,R,lat,lon,ellipsoid)
[zi,ri,lat,lon] = ...    mapprofile(Z,R,lat,lon,units,
   'trackmethod','interpmethod')
[zi,ri,lat,lon] = ...   mapprofile(Z,R,lat,lon,ellipsoid,
   'trackmethod','interpmethod')
```

Description

`mapprofile` plots a profile of values between waypoints on a displayed regular data grid. `mapprofile` uses the current object if it is a regular data grid, or the first regular data grid found on the current axes. The grid's `zdata` is used for the profile. The color data is used in the absence of `zdata`. The result is displayed in a new figure.

`[zi,ri,lat,lon] = mapprofile` returns the values of the profile without displaying them. The output `zi` contains interpolated values along great circles between the waypoints. `ri` is a vector of associated distances from the first waypoint in units of degrees of arc along the surface. `lat` and `lon` are the corresponding latitudes and longitudes.

`[zi,ri,lat,lon] = mapprofile(Z,R,lat,lon)` accepts as input a regular data grid and waypoint vectors. No displayed grid is required. Sets of waypoints may be separated by NaNs into line sequences. The output ranges are measured from the first waypoint within a sequence. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to or from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel.

`[zi,ri,lat,lon] = mapprofile(Z,R,lat,lon,units)` specifies the units of the output ranges along the profile. Valid range units inputs are any distance string recognized by `unitsratio`. Surface distances are computed using the default radius of the earth. If omitted, `'degrees'` are assumed.

`[zi,ri,lat,lon] = mapprofile(Z,R,lat,lon,ellipsoid)` uses the provided ellipsoid definition in computing the range along the profile. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The output range is reported in the same distance units as the semimajor axes of the ellipsoid. If omitted, the range vector is for a sphere.

`[zi,ri,lat,lon] = ...`
`mapprofile(Z,R,lat,lon,units,'trackmethod','interpmethod')`
and `[zi,ri,lat,lon] = ...`
`mapprofile(Z,R,lat,lon,ellipsoid,'trackmethod','interpmethod')`
control the interpolation methods used. Valid track methods are `'gc'` for great circle tracks between waypoints, and `'rh'` for rhumb lines. Valid methods for interpolation within the matrix are `'bilinear'` for linear interpolation, `'bicubic'` for cubic interpolation, and `'nearest'` for nearest neighbor interpolation. If omitted, `'gc'` and `'bilinear'` are assumed.

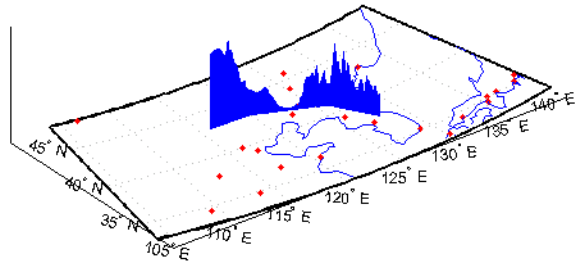
Examples

Example 1

Create a map axes for the Korean peninsula. Specify an elevation profile across the sample Korean digital elevation data and plot it, combined with a coastline and city markers:

```
load korea
h = worldmap(map, refvec); % The figure has no map content.
```

```
plat = [ 43  43  41  38];
plon = [116 120 126 128];
mapprofile(map, refvec, plat, plon)
load coast
plotm(lat, long)
geoshow('worldcities.shp', 'Marker', '.', 'Color', 'red')
```

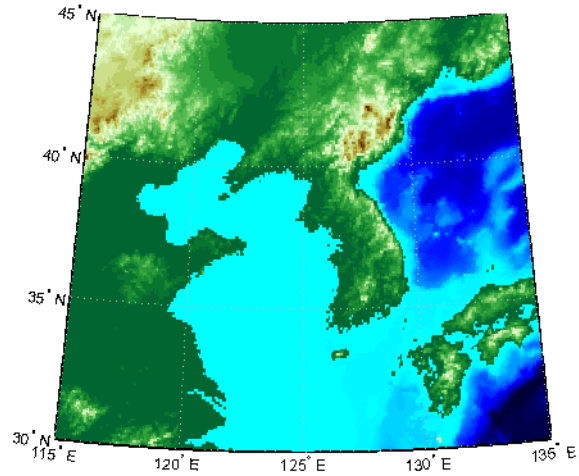


When you select more than two waypoints, the automatically generated figure displays the result in three dimensions. The following example shows the relative sizes of the mountains in northern China compared to the depths of the Sea of Japan. The call to `mapprofile` without input arguments requires you to interactively pick waypoints on the figure using the mouse, and press **Enter** after you select the final point:

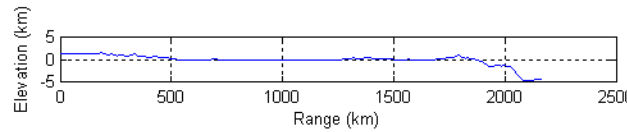
```
axes(h);
meshm(map, refvec, size(map))
demcmap(map)
[zi,ri,lat,lon] = mapprofile
```

Adding output arguments suppresses the display of the results in a new figure. You can then use the results in further calculations or display the results yourself. Here the profile from the upper left to lower right is computed from waypoints interactively picked on the map (your profile will not be identical to what is shown below). The example converts ranges and elevations to kilometers and displays them in a new

figure, setting the vertical exaggeration factor to 20. With no vertical exaggeration, the changes in elevation would be almost too small to see.




```
figure
plot(deg2km(ri),zi/1000)
daspect([ 1 1/20 1 ]);
xlabel 'Range (km)'
ylabel 'Elevation (km)'
```



Naturally, the profile you get depends on the transect locations you pick.

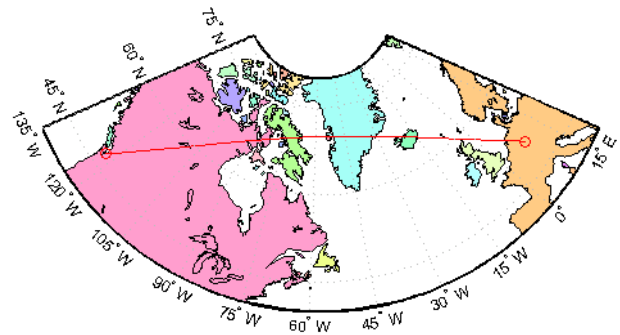
Example 2

You can compute values along a path without reference to an existing figure by providing a regular data grid and vectors of waypoint coordinates. Optional arguments allow control over the units of the

range output and interpolation methods between waypoints and data grid elements.

Show what land and ocean areas lie under a great circle track from Frankfurt to Seattle:

```
cities = shaperead('worldcities.shp', 'UseGeoCoords', true);
Seattle = strcmp('Seattle', {cities(:).Name});
Frankfurt = strcmp('Frankfurt', {cities(:).Name});
lat = [cities(Seattle).Lat cities(Frankfurt).Lat]
lon = [cities(Seattle).Lon cities(Frankfurt).Lon]
load topo
[valp,rp,latp,lonp] = ...
   mapprofile(double(topo),topolegend, ...
   lat,lon,'km','gc','nearest');
figure
worldmap([40 80],[-135 20])
land = shaperead('landareas.shp', 'UseGeoCoords', true);
faceColors = makesymbolspec('Polygon',...
   {'INDEX', [1 numel(land)], 'FaceColor', ...
   polcmap(numel(land))});
geoshow(land,'SymbolSpec',faceColors)
plotm(latp,lonp,'r')
plotm(lat,lon,'ro')
axis off
```



See Also

`ltln2val` | `los2`

maprasterref

Purpose

Construct `spatialref.MapRasterReference` object

Syntax

```
R = maprasterref()
R = maprasterref(Name,Value)
R = maprasterref(W, rasterSize, rasterInterpretation)
```

Description

`R = maprasterref()` constructs a `spatialref.MapRasterReference` object with default property values.

`R = maprasterref(Name,Value)` accepts a list of name-value pairs that are used to assign selected properties when initializing a `spatialref.MapRasterReference` object.

`R = maprasterref(W, rasterSize, rasterInterpretation)` constructs a `spatialref.MapRasterReference` object with the specified raster size and interpretation properties, and with remaining properties defined by a 2-by-3 world file matrix, `W`.

Input Arguments

W

2-by-3 world file matrix

rasterSize

Number of cells or samples in each spatial dimension. Two-element vector `[M N]` specifying the number of rows (*M*) and columns (*N*) of the raster or image associated with the referencing object. For convenience, you may assign a size vector having more than two elements to `RasterSize`. This flexibility enables assignments like `R.RasterSize = size(RGB)`, for example, where `RGB` is *M*-by-*N*-by-3. However, in such cases, only the first two elements of the size vector are actually stored. The higher (non-spatial) dimensions are ignored

rasterInterpretation

Controls handling of raster edges. This argument is optional and can equal either `'cells'` or `'postings'`.

Default: `'cells'`

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

You can include any of the following properties, overriding their default values as needed. Alternatively, you may omit any or all properties when constructing your `spatialref.MapRasterReference` object. Then, you can customize the result by resetting properties from this list one at a time. This name-value syntax always results in an object with a `'rectilinear' TransformationType`. If your image is rotated with respect to the world coordinate axes, you need an object with a `TransformationType` of `'affine'`. You can obtain such an object directly from the `spatialref.MapRasterReference` constructor. Alternately, you can provide an appropriate world file matrix as input, as shown in the third syntax. You cannot do it by resetting properties of an existing rectilinear `spatialref.MapRasterReference` object.

XLimWorld

Limits of raster in world *x*

Two-element row vector of the form `[xMin xMax]`.

Default: [0.5 2.5]

YLimWorld

Limits of raster in world *y*

Two-element row vector of the form `[yMin yMax]`.

Default: [0.5 2.5]

RasterSize

Two-element vector `[M N]` specifying the number of rows (*M*) and columns (*N*) of the raster or image associated with the referencing object. For convenience, you may assign a size vector having more than two elements to `RasterSize`. This flexibility enables assignments like `R.RasterSize = size(RGB)`, for example, where `RGB` is *M*-by-*N*-by-3. However, in such cases, only the first two elements of the size vector are actually stored. The higher (non-spatial) dimensions are ignored.

Default: [2 2]

RasterInterpretation

Controls handling of raster edges. A string that equals either `'cells'` or `'postings'`.

Default: `'cells'`

ColumnsStartFrom

Edge where column indexing starts. A string that equals either `'south'` or `'north'`.

Default: `'south'`

RowsStartFrom

Edge from which row indexing starts. A string that equals either `'west'` or 'east'.

Default: `'west'`

Output Arguments

R

`spatialref.MapRasterReference` object

Examples

Construct a referencing object for an 1000-by-2000 image with square, half-meter pixels referenced to a planar map coordinate system (the "world" system). The *X*-limits in the world system are 207000 and 208000. The *Y*-limits are 912500 and 913000. The image follows the

popular convention in which world *X* increases from column to column and world *Y* decreases from row to row.

```
% Override the default MATLAB display format. This is not strictly
% required, but tends to produces the most readable displays.
format short g

% Construct a spatialref.MapRasterReference object.
R = maprasterref('RasterSize', [1000 2000], ...
      'YLimWorld', [912500 913000], 'ColumnsStartFrom','north', ...
      'XLimWorld', [207000 208000])
```

Repeat the first example with a different strategy: Create a default object, and then modify that object's property settings as needed.

```
R = maprasterref;
R.XLimWorld = [207000 208000];
R.YLimWorld = [912500 913000];
R.ColumnsStartFrom = 'north';
R.RasterSize = [1000 2000]
```

Repeat the first example again, this time using a world file matrix.

```
W = [0.5   0.0   207000.25; ...
     0.0  -0.5   912999.75];
rasterSize = [1000 2000];
R = maprasterref(W, rasterSize)
```

See Also

`georasterref` | `spatialref.MapRasterReference`

spatialref.MapRasterReference

Purpose

Reference raster to map coordinates

Description

A `spatialref.MapRasterReference` object encapsulates the relationship between a planar map coordinate system and a system of *intrinsic coordinates* anchored to the columns and rows of a 2-D spatially referenced raster grid or image.

Typically, the raster is sampled regularly in the planar world x and world y coordinates of the map system, such that the intrinsic x and world x axes align and the intrinsic y and world y axes align. When this is true, the relationship between the two systems is rectilinear.

More generally, and much more rarely, their relationship is affine. The affine relationship allows for a possible rotation (and skew).

In either case, rectilinear or affine, the sample spacing from row to row need not equal the sample spacing from column to column. If the raster data set is interpreted as comprising a grid of cells or pixels, the cells or pixels need not be square. In the most general case, they could conceivably be parallelograms, but in practice they are always rectangular.

Construction

Construct a `MapRasterReference` object using either the:

- `maprasterref` function (recommended)
- `spatialref.MapRasterReference` class constructor
- `refmatToMapRasterReference` conversion function used to convert an existing referencing matrix

`R = maprasterref()` constructs a `MapRasterReference` object with these default property settings:

```
                  XLimWorld: [0.5 2.5]
                  YLimWorld: [0.5 2.5]
                 RasterSize: [2 2]
       RasterInterpretation: 'cells'
           ColumnsStartFrom: 'south'
```

```
          RowsStartFrom: 'west'
                 DeltaX: 1
                 DeltaY: 1
    RasterWidthInWorld: 2
   RasterHeightInWorld: 2
         XLimIntrinsic: [0.5 2.5]
         YLimIntrinsic: [0.5 2.5]
    TransformationType: 'rectilinear'
  CoordinateSystemType: 'planar'
```

Properties

XLimWorld

Limits of raster in world *x*.

Two-element row vector of the form `[xMin xMax]`.

Default: `[0.5000 2.5000]`

YLimWorld

Limits of raster in world *y*.

Two-element row vector of the form `[yMin yMax]`.

Default: `[0.5000 2.5000]`

RasterSize

Two-element vector `[M N]` specifying the number of rows (*M*) and columns (*N*) of the raster or image associated with the referencing object. For convenience, you can assign a size vector having more than two elements to `RasterSize`. This enables assignments like `R.RasterSize = size(RGB)`, where `RGB` is *M*-by-*N*-by-3. In cases like this, only the first two elements of the size vector are stored. Higher (non-spatial) dimensions are ignored. *M* and *N* must be positive in all cases and must be 2 or greater when `RasterInterpretation` is `'postings'`.

Default: `[2 2]`

RasterInterpretation

Controls handling of raster edges. A string that equals `'cells'` or `'postings'`.

Default: `'cells'`

ColumnsStartFrom

Edge where column indexing starts. A string that equals `'south'` or `'north'`.

Default: `'south'`

RowsStartFrom

Edge from which row indexing starts. A string that equals `'west'` or `'east'`.

Default: `'west'`

DeltaX

Cell width or sample spacing along rows. When you set `RasterInterpretation` to `'cells'`, `DeltaX` equals the cell width. When you set `RasterInterpretation` to `'postings'`, `DeltaX` is the sample spacing along rows, from column to column.

In the case of a rectilinear transformation, `DeltaX` is signed. A positive sign indicates that world x increases when intrinsic x increases, and a negative sign indicates otherwise. In the case of a general affine transformation, where the x-axes might not align, `DeltaX` also indicates either cell width or sample spacing along rows. In this case, `DeltaX` cannot have a meaningful sign, so it is strictly positive.

Cannot be set.

DeltaY

Cell height or sample spacing along columns. When you set `RasterInterpretation` to `'cells'`, `DeltaY` equals the cell height. When you set `RasterInterpretation` to `'postings'`, `DeltaY` is the sample spacing along columns, from row to row. In the case of a rectilinear transformation, `DeltaY` is signed. A positive sign indicates that world *y* increases when intrinsic *y* increases, and a negative sign indicates otherwise. In the case of a general affine transformation, where the *y*-axes might not align, `DeltaY` also indicates either cell height or sample spacing along columns. In this case, `DeltaY` cannot have a meaningful sign, so it is strictly positive.

Cannot be set.

RasterWidthInWorld

Extent of the full raster or image as measured in the world system in a direction parallel to its rows. In the case of a rectilinear geometry, which is most typical, this is the horizontal direction (east-west).

Cannot be set.

RasterHeightInWorld

Extent of the full raster or image as measured in the world system in a direction parallel to its columns. In the case of a rectilinear geometry, which is most typical, this is the vertical direction (north-south).

Cannot be set.

XLimIntrinsic

Raster limits in intrinsic *x*.

Two-element row vector of the form `[xMin xMax]`. For an *M*-by-*N* raster with `RasterInterpretation` equal to `'postings'`, it equals `[1 N]`. For `'cells'`, it equals `[0.5, N + 0.5]`.

Cannot be set.

YLimIntrinsic

Raster limits in intrinsic *y*

Two-element row vector of the form `[yMin yMax]`. For an *M*-by-*N* raster with `RasterInterpretation` equal to `'postings'`, it equals `[1 M]`. For `'cells'`, it equals `[0.5, M + 0.5]`.

Cannot be set.

TransformationType

Type of geometric relationship between the intrinsic coordinate system and the world coordinate system. The string has the value `'rectilinear'` or `'affine'`. Its value is `'rectilinear'` when world *x* depends only on intrinsic *x* and vice versa, and world *y* depends only on intrinsic *y* and vice versa. When the value is `'rectilinear'`, the image displays without rotation in the world system, although it might be flipped. Otherwise, the value is `'affine'`.

Cannot be set.

CoordinateSystemType

Type of coordinate system to which the image or raster is referenced. It is a constant string with value `'planar'`.

Cannot be set.

Methods

contains	True if raster contains points in world coordinate system
firstCornerX	World *x* coordinate of the (1,1) corner of the raster
firstCornerY	World *y* coordinate of the (1,1) corner of the raster
intrinsicToWorld	Convert from intrinsic to world coordinates

sizesMatch	True if object and raster or image are size compatible
worldFileMatrix	World file parameters for transformation
worldToIntrinsic	Convert from world to intrinsic coordinates
worldToSub	World coordinates to row and column subscripts

Definitions

Intrinsic Coordinate System

A 2-D Cartesian system with its *x*-axis running parallel to the rows of a raster or image and its *y*-axis running parallel to the columns. *x* increases by 1 from column to column, and *y* increases by 1 from row to row.

The Mapping Toolbox and Image Processing Toolbox use the convention for the location of the origin relative to the raster cells or sampling points such that, at a sample location or at the center of a cell, *x* has an integer value equal to the column index. Likewise, at a sample location or at the center of a cell, *y* has an integer value equal to the row index. For details, see Image Coordinate Systems in the Image Processing Toolbox documentation.

See Also

`maprasterref` | `refmatToMapRasterReference` | `spatialref.GeoRasterReference`

spatialref.MapRasterReference.contains

Purpose

True if raster contains points in world coordinate system

Syntax

```
TF = R.contains(xWorld, yWorld)
```

Description

`TF = R.contains(xWorld, yWorld)` returns a logical array `TF` having the same size as `xWorld` and `yWorld` such that `TF(k)` is `true` if and only if the point `(xWorld(k), yWorld(k))` falls within the bounds of the raster associated with referencing object `R`.

Purpose

World *x* coordinate of the (1,1) corner of the raster

Syntax

```
R.firstCornerX
```

Description

`R.firstCornerX` returns the world *x* coordinate of either the:

- Outermost corner of the first cell (1,1) of the raster associated with referencing object `R`, if `R.RasterInterpretation` is `'cells'`
- First sample point, if `R.RasterInterpretation` is `'postings'`

spatialref.MapRasterReference.firstCornerY

Purpose

World *y* coordinate of the (1,1) corner of the raster

Syntax

```
R.firstCornerY
```

Description

`R.firstCornerY` returns the world *y* coordinate of the:

- Outermost corner of the first cell (1,1) of the raster associated with referencing object `R`, if `R.RasterInterpretation` is `'cells'`
- First sample point, if `R.RasterInterpretation` is `'postings'`

Purpose

Convert from intrinsic to world coordinates

Syntax

```
[xWorld, yWorld] = R.intrinsicToWorld(xIntrinsic, yIntrinsic)
```

Description

`[xWorld, yWorld] = R.intrinsicToWorld(xIntrinsic, yIntrinsic)` maps point locations from the intrinsic system `(xIntrinsic, yIntrinsic)` to the world system `(xWorld, yWorld)` based on the relationship defined by the referencing object `R`. If your input includes values outside the limits of the raster or image in the intrinsic system, `intrinsicToWorld` extrapolates world x and y outside the bounds of the image in the world system.

spatialref.MapRasterReference.sizesMatch

Purpose

True if object and raster or image are size compatible

Syntax

```
TF = R.sizesMatch(A)
```

Description

`TF = R.sizesMatch(A)` returns `true` if the size of the raster or image `A` is consistent with the `RasterSize` property of referencing object `R`. That is:

```
R.RasterSize == [size(A,1) size(A,2)]
```

Purpose

World file parameters for transformation

Syntax

```
W = R.worldFileMatrix
```

Description

`W = R.worldFileMatrix` returns a 2-by-3 world file matrix. Each of the six elements in `W` matches one of the lines in a world file corresponding to the rectilinear or affine transformation defined by referencing object `R`.

Given `W` with the form:

```
W = [A B C;
     D E F]
```

a point `(xi, yi)` in intrinsic coordinates maps to a point `(xw, yw)` in planar world coordinates like this:

```
xw = A * (xi   1) + B * (yi   1) + C
yw = D * (xi   1) + E * (yi   1) + F
```

More compactly:

```
[xw yw]' = W * [xi - 1  yi - 1  1]'
```

The `1`s are needed to maintain the Mapping Toolbox convention for intrinsic coordinates, which is consistent with the 1-based indexing used throughout MATLAB.

`W` is stored in a world file with one term per line in column-major order: A, D, B, E, C, F. That is, a world file contains the elements of `W` in this order:

```
W(1,1)
W(2,1)
W(1,2)
W(2,2)
W(1,3)
W(2,3)
```

The previous expressions hold for both affine and rectilinear transformations. But whenever `R.TransformationType` is `'rectilinear'`, `B`, `D`, `W(2,1)` and `W(1,2)` are identically 0.

See Also

`worldfileread` | `worldfilewrite`

Purpose

Convert from world to intrinsic coordinates

Syntax

```
[xIntrinsic, yIntrinsic] = R.worldToIntrinsic(xWorld, yWorld)
```

Description

`[xIntrinsic, yIntrinsic] = R.worldToIntrinsic(xWorld, yWorld)` maps point locations from the world system (`xWorld`, `yWorld`) to the intrinsic system (`xIntrinsic`, `yIntrinsic`) based on the relationship defined by the referencing object `R`. The input can include values outside limits of the raster (or image) in the world system. In this case, world x and y are extrapolated outside the bounds of the image in the intrinsic system.

spatialref.MapRasterReference.worldToSub

Purpose

World coordinates to row and column subscripts

Syntax

```
[I,J] = R.worldToSub(xWorld, yWorld)
```

Description

`[I,J] = R.worldToSub(xWorld, yWorld)` returns subscript arrays `I` and `J`. When referencing object `R` has `RasterInterpretation 'cells'`, these are the row and column subscripts of the raster cells (or image pixels) containing each element of a set of points given their world coordinates `(xWorld, yWorld)`. If `R.RasterInterpretation` is `'postings'`, then the subscripts refer to the nearest sample point (posting). `xWorld` and `yWorld` must have the same size. `I` and `J` have the same size as `xWorld` and `yWorld`. For an *M*-by-*N* raster, `1 <= I <= M` and `1 <= J <= N`, except when a point `xWorld(k)`, `yWorld(k)` falls outside the image, as defined by `R.contains(xWorld,yWorld)`. Then both `I(k)` and `J(k)` are NaN.

Purpose

List available map projections and verify names

Syntax

```
strmat = maps('namelist')
strmat = maps('idlist')
stdstr = maps(id_string)
```

Description

`maps` displays in the Command Window a table describing all projections available for use.

`strmat = maps('namelist')` returns the English names for the available projections as a matrix of strings.

`strmat = maps('idlist')` returns the standard projection identification strings for the available projections as a matrix of strings.

`stdstr = maps(id_string)` returns the specific standard projection identification string associated with a unique truncation abbreviation.

Examples

To show the first five entries of the projections name list,

```
str1 = maps('namelist');
str1(1:5,:)
ans =
Balthasart Cylindrical
Behrmann Cylindrical
Bolshoi Sovietskii Atlas Mira
Braun Perspective Cylindrical
Cassini Cylindrical
```

The corresponding shorthand names are

```
str2 = maps('idlist');
str2(1:5,:)
ans =
balthsrt
behrmann
bsam
braun
cassini
```

These are the strings used, for example, when setting the `axesm` property `MapProjection`.

The functions `setm` and `axesm` recognize unique abbreviations (truncations) of these strings. The `maps` function can be used to convert such an abbreviation to the standard ID string:

```
stdstr = maps('merc')
stdstr =
mercator
```

When the function name alone is used,

```
maps

MapTools Projections
CLASS             NAME                                ID STRING
Cylindrical       Balthasart Cylindrical              balthsrt
Cylindrical       Behrmann Cylindrical                behrmann
Cylindrical       Bolshoi Sovietskii Atlas Mira*      bsam
Cylindrical       Braun Perspective Cylindrical*      braun
Cylindrical       Cassini Cylindrical                 cassini
Cylindrical       Central Cylindrical*                ccylin
Cylindrical       Equal Area Cylindrical              eqacylin
Cylindrical       Equidistant Cylindrical             eqdcylin
Cylindrical       Gall Isographic                     giso...
```

The actual result contains all defined projections.

See Also

`axesm` | `setm`

Purpose

Planar shape vector

Syntax

```
s = mapshape()
s = mapshape(x,y)
s = mapshape(x,y,Name,Value)
s = mapshape(structArray)
s = mapshape(x,y,structArray)
```

Description

A mapshape vector is an object that represents planar vector features with either point, line, or polygon topology. The features consist of X and Y coordinates and associated attributes. If these attributes vary spatially they are termed Vertex properties. These elements of the mapshape vector are coupled such that the length of the X and Y coordinate property values are always equal in length to any additional dynamic Vertex properties. Attributes which only pertain to the overall feature (point, line, polygon) are termed Feature properties. Feature properties are not linked to the auto-sizing mechanism of the Vertex properties. Both of the property types can be dynamically added to a mapshape vector using the standard dot notation.

A mapshape vector is always a column vector.

Construction

`s = mapshape()` constructs an empty mapshape vector, `s`, with the following default property settings.

```
s =

 Ox1 mapshape vector with properties:

 Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
 Vertex properties:
           X: []
           Y: []
```

For an additional example see: “Constructor: mapshape()” on page 3-726

`s = mapshape(x,y)` constructs a mapshape vector and sets the `X` and `Y` property values equal to vectors `x` and `y`. `x` and `y` may be either numeric vectors of class single or double, or cell arrays containing numeric vectors of class single or double. For an example, see "Constructor: mapshape(x,y)" on page 3-726.

`s = mapshape(x,y,Name,Value)` constructs a mapshape vector from the input `x` and `y` vectors, and then adds dynamic properties to the mapshape vector using the `Name`, `Value` argument pairs.

- If `Value` is in a cell array containing numeric, logical or cell array of strings, then this property is designated as a Vertex property. Otherwise, this property is designated as a Feature property.
- If the specified `Name` is `Metadata` and the corresponding `Value` is a scalar structure, then `Value` is copied to the `Metadata` property. Otherwise, an error is issued.

For an example, see: "Constructor: mapshape(x,y,Name,Value)" on page 3-727.

`s = mapshape(structArray)` constructs a `mapshape` vector from the fields of the structure array, `structArray`.

- If `structArray` is a scalar structure which contains the field `Metadata` and the field value is a scalar structure, then the `Metadata` field is copied to the `Metadata` property. If `structArray` is a scalar structure and the `Metadata` field is present and is not a scalar structure, then an error is issued. If `structArray` is not scalar then the `Metadata` field is ignored.
- Other fields of `structArray` are assigned to `s` and become dynamic properties. Field values in `structArray` that are not numeric, strings, logical, or cell arrays of numeric, logical, or string values are ignored.

For an example, see "Constructor: mapshape(structArray)" on page 3-727.

`s = mapshape(x,y,structArray)` constructs a new `mapshape` vector and sets the `X` and `Y` properties equal to the numeric vectors, `x` and `y`, and sets the field values of struct `structArray` as dynamic properties.

- If `structArray` is a scalar structure and contains the field `Metadata`, and the field value is a scalar structure, then it is copied to the `Metadata` property value. Otherwise, an error is issued if the `Metadata` field is not a structure, or ignored if `structArray` is not scalar.

For an example, see "Constructor: mapshape(x,y,structArray)" on page 3-728.

Input Arguments

x

vector of X coordinates

Data Types
double | single | cell

y

vector of Y coordinates

Data Types
double | single | cell

structArray

An array of structures containing fields to be assigned as dynamic properties.

Name

Name of dynamic property

Data Types
char

Value

Property value associated with dynamic property `Name`. The class type of the values for the Feature dynamic properties may be either numeric, logical, char, or a cell array of strings. Values for the Vertex dynamic properties may be either numeric, logical, cell array of strings, or a cell array of numeric, logical, or cell array of strings.

Output Arguments

s

mapshape vector.

Properties

`mapshape` class is a general class that represents a variety of planar features. The class permits features to have more than one vertex and can thus represent lines and polygons in addition to multipoints. The class has the following property types.

Types of Properties	Description
Collection Properties	Collection properties contain only one value per class instance. This is in contrast to the other two property types which can have attribute values associated with each feature or with each vertex in a set that defines a feature. Geometry and Metadata are the only two Collection properties.
Vertex Properties	Vertex properties provide a scalar number or a string for each vertex in a mapshape object. Vertex properties are suitable for attributes that vary spatially from point to point (vertex to vertex) along a line. Examples of such spatially varying attributes could be elevation, speed, temperature, or time. X and Y are vertex properties since they contain a scalar number for each vertex in a mapshape vector. Attribute values can be dynamically associated with each vertex by using dot

Types of Properties	Description
	notation. This is similar to adding dynamic fields to a structure. The dynamically added vertex property values of an individual feature match its X and Y values in length.
Feature Properties	Feature properties provide one value (a scalar number or a string) for each feature in a mapshape vector. They are suitable for properties, such as name, owner, serial number, age, etc., that describe a given feature (an element of a mapshape vector) as a whole. Like Vertex properties, Feature properties can be added dynamically.

Geometry

The `Geometry` property is a string that denotes the shape type for all the features in the mapshape vector. As a Collection Property there is only one value per object instance. Its purpose is purely informational; the three allowable string values for `Geometry` do not change class behavior. Additionally, the class does not provide validation for line or polygon topologies.

Default value for `Geometry` is `` `line' ``.

`Geometry`	`'point', 'line', 'polygon'`

Metadata

Metadata is a scalar structure containing information for all the features. You can add any data type to the structure. As a Collection Property type, only one instance per object is allowed.

`Metadata`	`Scalar struct`

X

Vector of X coordinates. The values can be either a row or column vector, but are stored as a row vector.

Attributes:

X	single | double vector

Y

Vector of Y coordinates. The values can be either a row or column vector, but are stored as a row vector.

Attributes:

Y	single | double vector

Methods

append	Append features to mapshape vector
cat	Concatenate mapshape vectors
disp	Display mapshape vector
fieldnames	Dynamic properties of mapshape vector
isempty	True if mapshape vector is empty
isfield	True if dynamic property exists
isprop	True if property exists
length	Number of elements in mapshape vector
properties	Properties of a mapshape vector
rmfield	Remove dynamic property from mapshape vector
rmprop	Remove properties from mapshape vector
size	Size of mapshape vector

struct	Convert mapshape vector to scalar structure
vertcat	Vertical concatenation for mapshape vectors

Copy Semantics

Value. To learn how value classes affect copy operations, see Copying Objects in the MATLAB Programming Fundamentals documentation.

Class Behaviors

- The following examples show how to build a mapshape vector by dynamically adding a single features after construction using dot (.) notation.

  "Add a Feature Property" on page 3-729

- The following extended example adds multiple features that are both Vertex and Feature properties. It also demonstrates property behaviors when vector lengths are either changed or set to [ ].

  "Add Multiple Features" on page 3-730

- This example uses the Name-Value constructor to build a mapshape vector and define two dynamic features.

  "Two Features defined by Name-Value pairs" on page 3-735

- The mapshape vector can be indexed like any MATLAB vector. You can access any element of the vector to obtain a specific feature. The following example demonstrates this behavior.

  "Multiple Features and Indexing Behaviors" on page 3-736

- This example builds a mapshape vector from a structure array; adds a Metadata property and demonstrates selective indexing behavior.

  "Structure Array, add Metadata and Indexing" on page 3-739

- The following example shows a variety of indexing behaviors.

  "Indexing Behaviors" on page 3-741

- If either X or Y is set to [ ], then both coordinate properties are set to [ ] and all dynamic Vertex or Feature properties are removed.
- If a Vertex or Feature property is set to [ ], then it is removed from the object.

Examples

Constructor: mapshape()

Construct a default mapshape vector, dynamically set the X and Y property values, and dynamically add Vertex property Z.

```
s = mapshape();
s(1).X = 0:45:90;
s(1).Y= [10 10 10];
s(1).Z = [10 20 30]
```

```
s =

 1x1 mapshape vector with properties:

 Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
 Vertex properties:
           X: [0 45 90]
           Y: [10 10 10]
           Z: [10 20 30]
```

Constructor: mapshape(x,y)

Construct a mapshape vector from X and Y values.

```
x = [40, 50, 60];
y = [10, 20, 30];
shape = mapshape(x, y)
```

```
shape =

 1x1 mapshape vector with properties:
```

```
 Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
 Vertex properties:
           X: [40 50 60]
           Y: [10 20 30]
```

Constructor: mapshape(x,y,Name,Value)

Construct a mapshape vector with one feature from a single position coordinate, and a `Name`,`Value` pair defining a 'Temperature' Feature property.

```
x = 1:10;
y = 21:30;
temperature = {61:70};
shape = mapshape(x, y, 'Temperature', temperature)

shape =

 1x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
 Vertex properties:
              X: [1 2 3 4 5 6 7 8 9 10]
              Y: [21 22 23 24 25 26 27 28 29 30]
    Temperature: [61 62 63 64 65 66 67 68 69 70]
```

When `Value` is a cell array containing numeric, logical, or cell array of strings, it is construed as a Vertex property. Otherwise the `Name-Value` pair is designated as being a Feature property.

Constructor: mapshape(structArray)

Construct a mapshape vector from a structure array.

```
structArray = shaperead('concord_roads');
```

```
    shape = mapshape(structArray)

shape =

 609x1 mapshape vector with properties:

 Collection properties:
      Geometry: 'line'
      Metadata: [1x1 struct]
 Vertex properties:
  (609 features concatenated with 608 delimiters)
             X: [1x5422 double]
             Y: [1x5422 double]
 Feature properties:
    STREETNAME: {1x609 cell}
     RT_NUMBER: {1x609 cell}
         CLASS: [1x609 double]
    ADMIN_TYPE: [1x609 double]
        LENGTH: [1x609 double]
```

Constructor: mapshape(x,y,structArray)

Construct a mapshape vector using cell arrays to define multifeatures and a structure array to define a set of Feature properties.

```
[structArray, A] = shaperead('concord_hydro_area');
shape = mapshape({structArray.X}, {structArray.Y}, A);
shape.Geometry = structArray(1).Geometry

shape =

 98x1 mapshape vector with properties:

 Collection properties:
     Geometry: 'polygon'
     Metadata: [1x1 struct]
 Vertex properties:
  (98 features concatenated with 97 delimiters)
```

```
           X: [1x4902 double]
           Y: [1x4902 double]
 Feature properties:
         AREA: [1x98 double]
    PERIMETER: [1x98 double]
```

Add a Feature Property

Construct a mapshape vector from x and y coordinates and add a Feature Property.

```
x = 0:10:100;
y = 0:10:100;
shape = mapshape(x, y)

shape =

 1x1 mapshape vector with properties:

 Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
 Vertex properties:
           X: [0 10 20 30 40 50 60 70 80 90 100]
           Y: [0 10 20 30 40 50 60 70 80 90 100]
```

Add a feature dynamic property.

```
shape.FeatureName = 'My Feature'

shape =

 1x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
 Vertex properties:
              X: [0 10 20 30 40 50 60 70 80 90 100]
```

```
             Y: [0 10 20 30 40 50 60 70 80 90 100]
 Feature properties:
    FeatureName: 'My Feature'
```

Add a vertex dynamic property to the first feature.

```
shape(1).Temperature = 65 + rand(1, length(shape.X))
```

```
shape =

 1x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
 Vertex properties:
             X: [0 10 20 30 40 50 60 70 80 90 100]
             Y: [0 10 20 30 40 50 60 70 80 90 100]
    Temperature: [1x11 double]
 Feature properties:
    FeatureName: 'My Feature
```

Add Multiple Features

Construct a mapshape vector for two features, and show class behaviors.

```
x = {1:3, 4:6};
y = {[0 0 0], [1 1 1]};
shape = mapshape(x, y)
```

```
shape =

 2x1 mapshape vector with properties:

 Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
 Vertex properties:
```

```
  (2 features concatenated with 1 delimiter)
          X: [1 2 3 NaN 4 5 6]
          Y: [0 0 0 NaN 1 1 1]
```

Add a two element feature dynamic property.

```
shape.FeatureName = {'Feature 1', 'Feature 2'}

shape =

 2x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
 Vertex properties:
  (2 features concatenated with 1 delimiter)
              X: [1 2 3 NaN 4 5 6]
              Y: [0 0 0 NaN 1 1 1]
 Feature properties:
    FeatureName: {'Feature 1' 'Feature 2'}
```

Add a vertex dynamic property.

```
z = {101:103, [115, 114, 110]}
shape.Z = z

z =

    [1x3 double]    [1x3 double]


shape =

 2x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'line'
```

```
      Metadata: [1x1 struct]
 Vertex properties:
  (2 features concatenated with 1 delimiter)
             X: [1 2 3 NaN 4 5 6]
             Y: [0 0 0 NaN 1 1 1]
             Z: [101 102 103 NaN 115 114 110]
 Feature properties:
    FeatureName: {'Feature 1' 'Feature 2'}
```

Display the second feature.

```
shape(2)
```

```
ans =

 1x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
 Vertex properties:
             X: [4 5 6]
             Y: [1 1 1]
             Z: [115 114 110]
 Feature properties:
    FeatureName: 'Feature 2'
```

Add a third feature. The lengths of all the properties are synchronized.

```
shape(3).X = 5:9
```

```
shape =

 3x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
```

```
 Vertex properties:
  (3 features concatenated with 2 delimiters)
              X: [1 2 3 NaN 4 5 6 NaN 5 6 7 8 9]
              Y: [0 0 0 NaN 1 1 1 NaN 0 0 0 0 0]
              Z: [101 102 103 NaN 115 114 110 NaN 0 0 0 0 0]
 Feature properties:
    FeatureName: {'Feature 1' 'Feature 2' ''}
```

Set the values for the Z vertex property with fewer values than contained in X or Y. The Z values expand to match the length of X and Y.

```
shape(3).Z = 1:3

shape =

 3x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
 Vertex properties:
  (3 features concatenated with 2 delimiters)
              X: [1 2 3 NaN 4 5 6 NaN 5 6 7 8 9]
              Y: [0 0 0 NaN 1 1 1 NaN 0 0 0 0 0]
              Z: [101 102 103 NaN 115 114 110 NaN 1 2 3 0 0]
 Feature properties:
    FeatureName: {'Feature 1' 'Feature 2' ''}
```

Set the values for either coordinate property (X or Y) and all properties shrink in size to match the new vertex length of that feature.

```
shape(3).Y = 1

shape =

 3x1 mapshape vector with properties:

 Collection properties:
```

```
      Geometry: 'line'
      Metadata: [1x1 struct]
 Vertex properties:
  (3 features concatenated with 2 delimiters)
             X: [1 2 3 NaN 4 5 6 NaN 5]
             Y: [0 0 0 NaN 1 1 1 NaN 1]
             Z: [101 102 103 NaN 115 114 110 NaN 1]
 Feature properties:
    FeatureName: {'Feature 1' 'Feature 2' ''}
```

Set the values for the Z vertex property with more values % than contained in X or Y. All properties expand in length % to match Z.

```
shape(3).Z = 1:6

shape =

 3x1 mapshape vector with properties:

 Collection properties:
      Geometry: 'line'
      Metadata: [1x1 struct]
 Vertex properties:
  (3 features concatenated with 2 delimiters)
             X: [1 2 3 NaN 4 5 6 NaN 5 0 0 0 0 0]
             Y: [0 0 0 NaN 1 1 1 NaN 1 0 0 0 0 0]
             Z: [101 102 103 NaN 115 114 110 NaN 1 2 3 4 5 6]
 Feature properties:
    FeatureName: {'Feature 1' 'Feature 2' ''}
```

Remove the FeatureName property.

```
shape.FeatureName = []

shape =

 3x1 mapshape vector with properties:
```

```
 Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
 Vertex properties:
  (3 features concatenated with 2 delimiters)
           X: [1 2 3 NaN 4 5 6 NaN 5 0 0 0 0 0]
           Y: [0 0 0 NaN 1 1 1 NaN 1 0 0 0 0 0]
           Z: [101 102 103 NaN 115 114 110 NaN 1 2 3 4 5 6]
```

Remove all dynamic properties and set the object to empty.

```
shape.X = []

shape =

 0x1 mapshape vector with properties:

 Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
 Vertex properties:
           X: []
           Y: []
```

Two Features defined by Name-Value pairs

Construct a mapshape vector with two features by % specifying name-value pairs in the constructor.

```
x = {1:3, 4:6};
y = {[0 0 0], [1 1 1]};
z = {41:43, [56 50 59]};
name = {'Feature 1', 'Feature 2'};
id = [1 2];
shape = mapshape(x, y, 'Z', z, 'Name', name, 'ID', id)

shape =

 2x1 mapshape vector with properties:
```

```
 Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
 Vertex properties:
  (2 features concatenated with 1 delimiter)
           X: [1 2 3 NaN 4 5 6]
           Y: [0 0 0 NaN 1 1 1]
           Z: [41 42 43 NaN 56 50 59]
 Feature properties:
        Name: {'Feature 1' 'Feature 2'}
          ID: [1 2]
```

Multiple Features and Indexing Behaviors

Construct a mapshape vector to hold multiple features using data from the seamount MAT-file.

Add dynamic vertex properties to indicate the Z values. Add dynamic feature properties to indicate the color and level values. Include metadata information.

Load the data and create x, y, and z arrays. Create a level list to use to bin the z values.

```
seamount = load('seamount');
x = seamount.x; y = seamount.y; z = seamount.z;

levels = [unique(floor(seamount.z/1000)) * 1000; 0];
```

Construct a mapshape object and assign the X and Y vertex properties to the binned x and y values. Create a new Z vertex property to contain the binned z values. Add a Levels feature property to contain the lowest level value per feature.

```
shape = mapshape;
for k = 1:length(levels) - 1
   index = z >= levels(k) & z < levels(k+1);
   shape(k).X = x(index);
```

```
   shape(k).Y = y(index);
   shape(k).Z = z(index);
   shape(k).Level = levels(k);
end
```

Add a Color feature property to denote a color for that feature, and specify that the geometry is 'point'

```
shape.Color = {'red', 'green', 'blue', 'cyan', 'black'};
shape.Geometry = 'point'
```

```
shape =

 5x1 mapshape vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Vertex properties:
  (5 features concatenated with 4 delimiters)
           X: [1x298 double]
           Y: [1x298 double]
           Z: [1x298 double]
 Feature properties:
       Level: [-5000 -4000 -3000 -2000 -1000]
       Color: {'red' 'green' 'blue' 'cyan' 'black'}
```

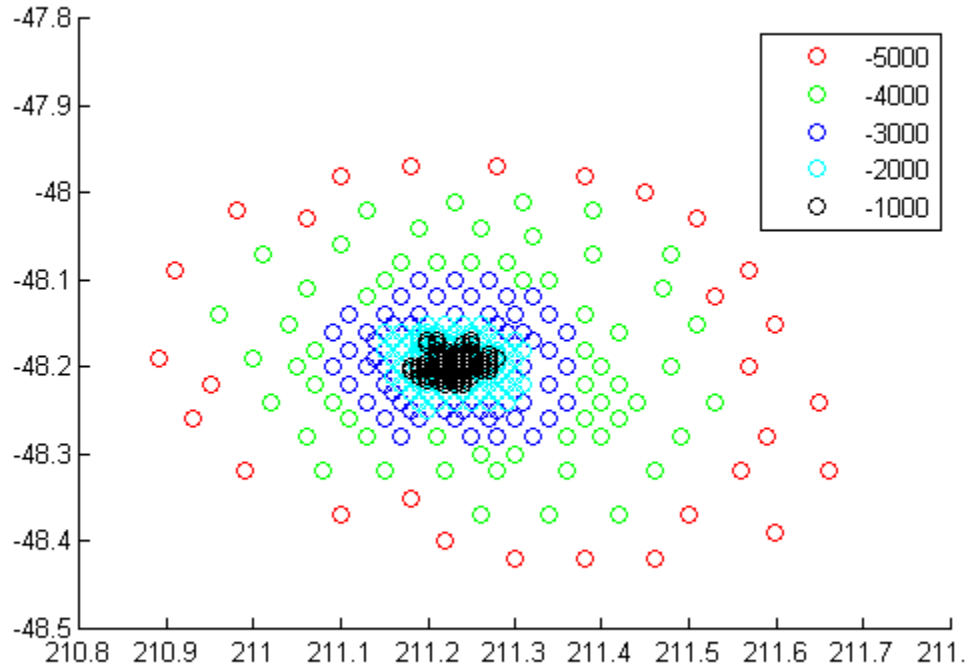
Add metadata information. Metadata is a scalar structure containing information for the entire set of properties. Any type of data may be added to the structure.

```
shape.Metadata.Caption = seamount.caption;
shape.Metadata
```

```
ans =

    Caption: [1x229 char]
```

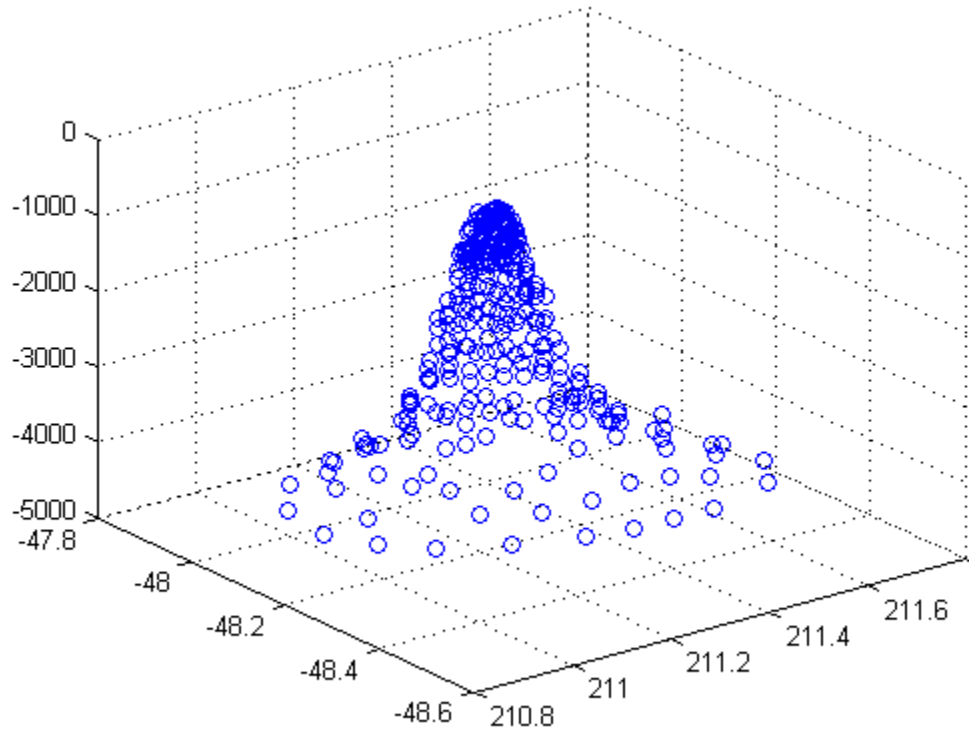
Display the point data in 2D.

```
figure
for k=1:length(shape)
  mapshow(shape(k).X, shape(k).Y, ...
   'MarkerEdgeColor', shape(k).Color, ...
   'Marker', 'o', ...
   'DisplayType', shape.Geometry)
end
legend(num2str(shape.Level'))
```



Display data as a 3-D scatter plot.

```
figure
scatter3(shape.X, shape.Y, shape.Z)
```



Structure Array, add Metadata and Indexing

This example demonstrates how to add to Metadata Collection property and indexing behavior.

Construct a mapshape vector from a structure array

```
filename = 'concord_roads.shp';
S = shaperead(filename);
shape = mapshape(S)

shape =

 609x1 mapshape vector with properties:

 Collection properties:
      Geometry: 'line'
      Metadata: [1x1 struct]
 Vertex properties:
  (609 features concatenated with 608 delimiters)
             X: [1x5422 double]
             Y: [1x5422 double]
 Feature properties:
    STREETNAME: {1x609 cell}
     RT_NUMBER: {1x609 cell}
         CLASS: [1x609 double]
    ADMIN_TYPE: [1x609 double]
        LENGTH: [1x609 double]
```

Add a Filename to the Metadata structure and then construct a new mapshape object with only CLASS 4 (major road) designation.

```
shape.Metadata.Filename = filename;
class4 = shape(shape.CLASS == 4)

class4 =

 26x1 mapshape vector with properties:

 Collection properties:
      Geometry: 'line'
      Metadata: [1x1 struct]
 Vertex properties:
  (26 features concatenated with 25 delimiters)
             X: [1x171 double]
```

```
            Y: [1x171 double]
 Feature properties:
    STREETNAME: {1x26 cell}
     RT_NUMBER: {1x26 cell}
         CLASS: [4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4]
    ADMIN_TYPE: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
        LENGTH: [1x26 double]
```

Indexing Behaviors

Construct a mapshape vector and sort the dynamic properties.

You can create a new mapshape vector that contains a subset of dynamic properties by adding the name of a property or a cell array of property names to the last index in the () operator.

Read data from file directly in mapshape constructor.

```
shape = mapshape(shaperead('tsunamis'))

shape =

 162x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Vertex properties:
  (162 features concatenated with 161 delimiters)
              X: [1x323 double]
              Y: [1x323 double]
 Feature properties:
          Cause: {1x162 cell}
     Cause_Code: [1x162 double]
        Country: {1x162 cell}
            Day: [1x162 double]
    Desc_Deaths: [1x162 double]
         Eq_Mag: [1x162 double]
           Hour: [1x162 double]
```

```
       Iida_Mag: [1x162 double]
      Intensity: [1x162 double]
       Location: {1x162 cell}
     Max_Height: [1x162 double]
         Minute: [1x162 double]
          Month: [1x162 double]
     Num_Deaths: [1x162 double]
         Second: [1x162 double]
       Val_Code: [1x162 double]
       Validity: {1x162 cell}
           Year: [1x162 double]
```

Alphabatize Feature properties.

```
shape = shape(:, sort(fieldnames(shape)))

shape =

 162x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'point'
       Metadata: [1x1 struct]
 Vertex properties:
  (162 features concatenated with 161 delimiters)
              X: [1x323 double]
              Y: [1x323 double]
 Feature properties:
          Cause: {1x162 cell}
     Cause_Code: [1x162 double]
        Country: {1x162 cell}
            Day: [1x162 double]
    Desc_Deaths: [1x162 double]
         Eq_Mag: [1x162 double]
           Hour: [1x162 double]
       Iida_Mag: [1x162 double]
      Intensity: [1x162 double]
```

```
      Location: {1x162 cell}
    Max_Height: [1x162 double]
        Minute: [1x162 double]
         Month: [1x162 double]
    Num_Deaths: [1x162 double]
        Second: [1x162 double]
      Val_Code: [1x162 double]
      Validity: {1x162 cell}
          Year: [1x162 double]
```

Modify the mapshape vector to contain only the specified dynamic properties.

```
shape = shape(:, {'Year', 'Month', 'Day', 'Hour', 'Minute'})

shape =

 162x1 mapshape vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Vertex properties:
  (162 features concatenated with 161 delimiters)
           X: [1x323 double]
           Y: [1x323 double]
 Feature properties:
        Year: [1x162 double]
       Month: [1x162 double]
         Day: [1x162 double]
        Hour: [1x162 double]
      Minute: [1x162 double]
```

Create a new mapshape vector in which each feature contains the points for the same year. Copy the data from a mappoint vector to ensure that NaN feature separators are not included. Create a subsection of data to include only Year and Country dynamic properties.

```
points = mappoint(shaperead('tsunamis'));
points = points(:, {'Year', 'Country'});
years = unique(points.Year);
multipoint = mapshape();
multipoint.Geometry = 'point';
for k = 1:length(years)
   index = points.Year == years(k);
   multipoint(k).X = points(index).X;
   multipoint(k).Y = points(index).Y;
   multipoint(k).Year = years(k);
   multipoint(k).Country = points(index).Country;
end
multipoint   % Display
```

```
multipoint =

 53x1 mapshape vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Vertex properties:
  (53 features concatenated with 52 delimiters)
           X: [1x214 double]
           Y: [1x214 double]
     Country: {1x214 cell}
 Feature properties:
        Year: [1x53 double]
```

Display the third from the end feature.

```
multipoint(end-3)
```

```
ans =

 1x1 mapshape vector with properties:

 Collection properties:
```

```
   Geometry: 'point'
   Metadata: [1x1 struct]
Vertex properties:
          X: [3.6340 -62.1800 143.9100]
          Y: [36.9640 16.7220 41.8150]
    Country: {'ALGERIA' 'MONTSERRAT' 'JAPAN'}
Feature properties:
       Year: 2003
```

See Also

geopoint | geoshape | mapshape | gpxread | shaperead

mapshape.append

Purpose

Append features to `mapshape` vector

Syntax

```
s = append(s,x,y)
s = append(s,x,y,Name,Value)
```

Description

`s = append(s,x,y)` appends the vector, `x`, to the `X` property values of the mapshape vector, `s`, and the vector, `y`, to the `Y` property values of `s`. `x` and `y` are either vectors of class single or double or cell arrays containing numeric arrays of class single or double.

`s = append(s,x,y,Name,Value)` appends the `x` and `y` vectors to the `X` and `Y` property values of the mapshape vector, `s`, and appends the values specified in the `Name,Value` pairs to the corresponding dynamic properties specified by the names in the `Name,Value` pairs if the properties are present in the object. Otherwise, the method adds dynamic properties to the object using the `Name` for the dynamic property names and assigns the corresponding `Value`.

Input Arguments

`s`

mapshape vector.

`X`

Numeric vector of planar `X` values.

`Y`

Numeric vector of planar `Y` values.

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

`Name,Value`

Parameter Name-Value pairs of the dynamic properties that are to be added to the mapshape vector, `s`.

Output Arguments

s

Modified mapshape vector with additional entries in `X` and `Y` fields along with any new fields for dynamic properties that you added.

Examples

Append Values to Fields in a mapshape vector

Append values to existing fields of a mapshape vector

```
shape = mapshape(42:44,30:32, 'Temperature', {65:67})
```

```
shape =

 1x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
 Vertex properties:
                X: [42 43 44]
                Y: [30 31 32]
      Temperature: [65 66 67]
```

Now append data representing another feature.

```
shape = append(shape, 42.1, 33, 'Temperature', 65.5)
```

```
shape =

 2x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
 Vertex properties:
```

```
(2 features concatenated with 1 delimiter)
            X: [42 43 44 NaN 42.1000]
            Y: [30 31 32 NaN 33]
  Temperature: [65 66 67 NaN 65.5000]
```

Note that the mapshape vector grew from 1x1 to 2x1 in length.

See Also

`mapshape` | `mapshape.vertcat` |

Purpose

Concatenate mapshape vectors

Syntax

```
s= cat(dim,s1, s2, ...)
```

Description

`s= cat(dim,s1, s2, ...)` concatenates the mapshape vectors `s1`,`s2` and so on along dimensions `dim`. `dim` must be `1`.

Input Arguments

`s1, s2, ...`

mapshape vectors to be concatenated.

Output Arguments

`s`

Concatenated mapshape vector.

Examples

Concatenate two mapshape vectors

Create two mapshape vectors and concatenate them into a single vector.

```
s1 = mapshape(42,-110, 'Temperature', 65);
s2 = mapshape(42.2, -110.5, 'Temperature', 65.6);
s1s2 = cat(1,s1,s2)

s1s2 =

 2x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
 Vertex properties:
  (2 features concatenated with 1 delimiter)
       X: [42 NaN 42.2000]
      Y: [-110 NaN -110.5000]
 Feature properties:
    Temperature: [65 65.6000]
```

See Also

`mapshape.vertcat` |

mapshape.disp

Purpose

Display mapshape vector

Syntax

```
disp(s)
```

Description

`disp(s)` prints the size of the mapshape vector, `s`, and its properties and dynamic properties, if they exist. If the command window is large enough, the values of the properties are also shown, otherwise only their size is shown. You can control the display of the numerical values by using the format command.

Input Arguments

`s`

mapshape vector.

Examples

Display a mapshape vector

Display a mapshape vector.

```
s = mapshape(shaperead('worldcities', 'UseGeo', true));
disp(s)
disp(s(1:2))
```

```
 318x1 mapshape vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Vertex properties:
  (318 features concatenated with 317 delimiters)
           X: [1x635 double]
           Y: [1x635 double]
 Feature properties:
         Lon: [1x318 double]
         Lat: [1x318 double]
        Name: {1x318 cell}

 2x1 mapshape vector with properties:
```

```
Collection properties:
   Geometry: 'point'
   Metadata: [1x1 struct]
Vertex properties:
 (2 features concatenated with 1 delimiter)
          X: [0 NaN 0]
          Y: [0 NaN 0]
Feature properties:
        Lon: [-3.9509 54.7589]
        Lat: [5.2985 24.6525]
       Name: {'Abidjan' 'Abu Dhabi'}
```

See Also

formatmapshape |

mapshape.fieldnames

Purpose

Dynamic properties of mapshape vector

Syntax

```
names = fieldnames(s)
```

Description

`names = fieldnames(s)` returns the names of the dynamic properties of the mapshape vector, `s`.

Input Arguments

`s`

mapshape vector for which the properties are to be queried.

Output Arguments

`names`

Names of the dynamic properties in the mapshape vector `s`

Examples

Find dynamic properties

Return the dynamic properties of a mapshape vector

```
s = mapshape(shaperead('worldcities'))
fieldnames(s)
```

```
s =

 318x1 mapshape vector with properties:

 Collection properties:
    Geometry: 'point'
    Metadata: [1x1 struct]
 Vertex properties:
  (318 features concatenated with 317 delimiters)
           X: [1x635 double]
           Y: [1x635 double]
 Feature properties:
        Name: {1x318 cell}


ans =
```

```
'Name'
```

See Also mapshape.properties |

mapshape.isempty

Purpose

True if mapshape vector is empty

Syntax

```
tf = isempty(s)
```

Description

`tf = isempty(s)` returns true if the mapshape vector, `s`, is empty and false otherwise.

Input Arguments

`s`

mapshape vector.

Output Arguments

`tf`

`Boolean`. 1 if `s` is empty or 0 if not.

Examples

Check if a mapshape vector is empty

Check if the mapshape vector is empty.

```
s = mapshape();
isempty(s)
```

```
ans =

     1
```

See Also

`mapshape.end` |

Purpose

True if dynamic property exists

Syntax

```
tf = isfield(s,name)
tf = isfield(s,names)
```

Description

`tf = isfield(s,name)` returns true if the value specified by the string `name` is a dynamic property of the mapshape vector, `s`.

`tf = isfield(s,names)` return true for each element of the cell array, `names`, that is a dynamic property of `s`. `tf` is a logical array of the same size as `names`.

Input Arguments

s

mapshape vector.

name

Name of the dynamic property.

names

Cell array of names of dynamic properties.

Output Arguments

tf

`Boolean`. 1 if `s` contains the specified fields or 0 otherwise.

Examples

Check for fieldname

Check if a field is present in a mapshape vector.

```
s = mapshape(-33.961, 18.484, 'Name', 'Cape Town')
isfield(s, 'X')
isfield(s, 'Name')

s =

 1x1 mapshape vector with properties:
```

```
 Collection properties:
    Geometry: 'line'
    Metadata: [1x1 struct]
 Vertex properties:
           X: -33.9610
           Y: 18.4840
 Feature properties:
        Name: 'Cape Town'


ans =

     0


ans =

     1
```

Note that `X` returns 0 because it is not a dynamically added property.

See Also

`mapshape.isprop` | `mapshape.fieldnames` |

Purpose

True if property exists

Syntax

```
tf = isprop(s,name)
tf = isprop(s,names)
```

Description

`tf = isprop(s,name)` returns true if the value specified by the string, `name` is a property of the mapshape vector, `s`.

`tf = isprop(s,names)` returns true for each element of the cell array of strings, `names`, that is a property of `s`. `tf` is a logical array the same size as `names`.

Input Arguments

s

mapshape vector.

name

String specifying the property of the mapshape vector, `s`.

names

Cell array of strings specifying the property of the mapshape vector, `s`.

Output Arguments

tf

Boolean. 1 if the property exists with `s` ,0 otherwise.

Examples

Check if property exists

This example shows how to check if a string is a property of a mapshape vector.

```
s = mapshape(-33.961, 18.484, 'Name', 'Cape Town');
isprop(s, 'X')
isprop(s, 'Name')
```

```
ans =

     1
```

```
ans =

     1
```

See Also

mapshape.isfield | mapshape.properties |

Purpose

Number of elements in mapshape vector

Syntax

```
N = length(s)
```

Description

`N = length(s)` returns the number of elements contained in the mapshape vector, `s`. The result is equivalent to `size(s,1)`.

Input Arguments

`s`

mapshape vector.

Output Arguments

`N`

Length of the mapshape vector, `s`.

Examples

Find the length of the mapshape vector.

```
coast = load('coast');
s = mapshape(coast.lat, coast.long);
length(s)
length(coast.lat)
```

```
ans =

     1


ans =

        9865
```

See Also

`mapshape.size` |

mapshape.properties

Purpose

Properties of a mapshape vector

Syntax

```
prop = properties(s)
properties(s)
```

Description

`prop = properties(s)` returns a cell of the property names of the mapshape vector, `s`.

`properties(s)` displays the names of the properties of `s`.

Input Arguments

`s`

mapshape vector.

Output Arguments

`prop`

Cell variable consisting of property names of the mapshape vector, `s`.

Examples

Properties of a mapshape vector

Query for properties of a mapshape vector.

```
s = mapshape(shaperead('tsunamis', 'UseGeo', true));
properties(s)
```

```
Properties for class mapshape:

    Geometry
    Metadata
    X
    Y
    Lon
    Lat
    Year
    Month
    Day
    Hour
```

```
Minute
Second
Val_Code
Validity
Cause_Code
Cause
Eq_Mag
Country
Location
Max_Height
Iida_Mag
Intensity
Num_Deaths
Desc_Deaths
```

See Also

`mapshape.fieldnames` |

mapshape.rmfield

Purpose

Remove dynamic property from mapshape vector

Syntax

```
s = rmfield(s, fieldname)
s = rmfield(s, fields)
```

Description

`s = rmfield(s, fieldname)` removes the field specified by the string, `fieldname` , from the mapshape vector, `s`.

`s = rmfield(s, fields)` removes all the fields specified by the cell array, `fields`.

Note `rmfield` cannot remove `X`, `Y`, `Metadata` and `Geometry` fields. The specified string, '`fieldname`, is case sensitive.

Input Arguments

s

mapshape vector.

fieldname

Exact string representing the name of the property.

fields

Cell array of strings specifying the names of the properties.

Output Arguments

s

Updated mapshape vector with the field(s) removed.

Examples

Remove fields from a mapshape vector

Remove a field from a mapshape vector.

```
s = mapshape(shaperead('tsunamis'));
tf = isfield(s,'Intensity')
s2 = rmfield(s,'Intensity');
tf = isfield(s2,'Intensity')
```

```
tf =

     1

tf =

     0
```

See Also

mapshape.fieldnames | mapshape.rmprop |

mapshape.rmprop

Purpose

Remove properties from mapshape vector

Syntax

```
sf = rmprop(s,propname)
sf = rmprop(s,propnames)
```

Description

`sf = rmprop(s,propname)` removes the property specified by the string, `propname` from the mapshape vector, `s`.

`sf = rmprop(s,propnames)` removes all the properties specified in the cell array, `propnames`, from the mapshape vector, `s`. If `propnames` contains a coordinate property an error is issued.

Note `rmprop` cannot remove `X`, `Y`, `Metadata` and `Geometry` fields. The specified string, `propname`, is case sensitive.

Input Arguments

s

mapshape vector.

Output Arguments

sf

Modified mapshape vector with the specified property(s) removed.

Examples

Remove a property of a mapshape vector

Remove a property from a mapshape vector.

```
s = mapshape(shaperead('tsunamis'));
tf = isfield(s,'Validity')
s2 = rmprop(s, 'Validity');
tf = isfield(s2,'Validity')
```

```
tf =

     1
```

```
tf =

     0
```

See Also `mapshape.fieldnames` |

mapshape.size

Purpose

Size of `mapshape` vector

Syntax

```
val = size(s)
val = size(s,1)
val = size(s, n)
[m,k] = size(s)
```

Description

`val = size(s)` returns the vector `[length(val), 1]`.

`val = size(s,1)` returns the length of `s`.

`val = size(s, n)` returns `1` for `n >= 2`.

`[m,k] = size(s)` returns `length(s)` for `m` and `1` for `k`.

Input Arguments

s

mapshape vector.

n

Number of the dimension at which size of `s` is required.

Output Arguments

val

Vector of the form `[length(s), 1]`.

m

Length of `s`.

k

Length of second dimension of `s`. `k` is always `1`.

Examples

Size of a mapshape vector

Find the size of a mapshape vector.

```
structArray = shaperead('worldrivers');
s= mapshape(structArray);
structSize = size(structArray)
```

```
sSize = size(s)

structSize =

   128     1


sSize =

   128     1
```

The second dimension is always 1.

See Also

`geoshape.length` | `size`

mapshape.struct

Purpose

Convert mapshape vector to scalar structure

Syntax

```
structArray = struct(s)
```

Description

`structArray = struct(s)` converts the mapshape vector, `s`, to a scalar structure array, `structArray`.

Input Arguments

s

mapshape vector.

Output Arguments

structArray

Scalar structure of the mapshape vector `s`.

Examples

Converting a mapshape vector into struct

This example shows how to convert a mapshape vector to `struct`.

```
structArray = shaperead('worldcities')
s= mapshape(structArray);
structArray2 = struct(s)

structArray =

318x1 struct array with fields:
    Geometry
    X
    Y
    Name


structArray2 =

    Geometry: 'point'
    Metadata: [1x1 struct]
           X: [1x635 double]
           Y: [1x635 double]
```

```
    Name: {1x318 cell}
```

See Also

geoshape.properties |

mapshape.vertcat

Purpose

Vertical concatenation for mapshape vectors

Syntax

```
s = vertcat(s1,s2, ...)
```

Description

`s = vertcat(s1,s2, ...)` vertically concatenates the mapshape vector, `s1, s2,` and so on. If the class type of any property is a cell array, then the resultant field in the output `s` will also be a cell array.

Input Arguments

`s1, s2, ...`

mapshape vectors to be concatenated.

Output Arguments

`s`

Concatenated mapshape vector.

Examples

Concatenate mapshape vectors

Concatenate two mapshape vectors.

```
s1 = mapshape(42, -110, 'Temperature', 65, 'Name', 'point1');
s2 = mapshape( 42.1, -110.4, 'Temperature', 65.5, 'Name', 'point2');
s = vertcat(s1, s2)
```

```
s =

 2x1 mapshape vector with properties:

 Collection properties:
       Geometry: 'line'
       Metadata: [1x1 struct]
 Vertex properties:
  (2 features concatenated with 1 delimiter)
              X: [42 NaN 42.1000]
              Y: [-110 NaN -110.4000]
 Feature properties:
    Temperature: [65 65.5000]
           Name: {'point1' 'point2'}
```

See Also `mapshape.cat` |

mapshow

Purpose

Display map data without projection

Syntax

```
mapshow(x,y)
mapshow(s)
mapshow(x,y,z)
mapshow(Z,R)
mapshow(x,y,image)
mapshow(x,y,A,cmap)
mapshow(image,R)
mapshow(A,cmap,R)
mapshow(ax,...)
mapshow('Parent',ax,...)
mapshow(filename)
mapshow(...,Name,Value)
h = mapshow(...)
```

Description

`mapshow(x,y)` displays the coordinate vectors `x` and `y`. The default behavior for `mapshow` is to display `x` and `y` as lines.

`mapshow(s)` displays the vector geographic features stored in the geographic data structure `s` as points, multipoints, lines, or polygons according to the Geometry field of `s`. If `s` includes `X` and `Y` fields, then these fields are used directly to plot features in map coordinates. If `s` includes `Lat` and `Lon` fields instead, the coordinates are projected with the Plate Carrée projection and a warning is issued.

`mapshow(x,y,z)` displays a geolocated data grid. `x` and `y` are *M*-by-*N* coordinate arrays, and `z` is an *M*-by-*N* array of class `double`.

`mapshow(Z,R)` displays a regular data grid, `Z`.

`mapshow(x,y,image)` or `mapshow(x,y,A,cmap)` displays a geolocated image as a texturemap on a zero-elevation surface. `x` and `y` are geolocation arrays in map coordinates. `x`, `y`, and the image array must match in size. Examples of geolocated images include a color composite from a satellite swath or an image originally referenced to a different coordinate system.

`mapshow(image,R)` or `mapshow(A,cmap,R)` displays an image georeferenced to map coordinates through `R`. The `mapshow` function constructs an image object if the display geometry permits. Otherwise, `mapshow` displays the image as a texturemap on a zero-elevation surface.

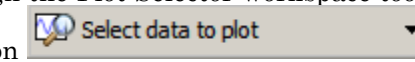
`mapshow(ax,...)` and `mapshow('Parent',ax,...)` set the axes parent to `ax`.

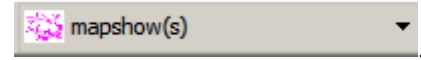
`mapshow(filename)` displays data from the file specified according to the type of file format.

`mapshow(...,Name,Value)` specifies parameters and corresponding values that modify the type of display or set MATLAB graphics properties. Parameter names can be abbreviated, and case does not matter.

`h = mapshow(...)` returns a handle to a MATLAB graphics object.

Tips

- If you do not want `geoshow` to draw on top of an existing map, create a new figure or subplot before calling it.
- You can use `mapshow` to display vector data in an `axesm` figure. However, you should not subsequently change the map projection using `setm`.
- If you display a polygon, do not set `'EdgeColor'` to either `'flat'` or `'interp'`. This combination may result in a warning.
- You can access `mapshow` through the Plot Selector workspace tool, which is represented by this icon 

. In your workspace, select the data you want to display. The Plot Selector icon changes to look like this: 

. Scroll down to **mapshow(s): Plot a mapstruct array in an ordinary axes**.
- If `s` is a geostruct (has `Lat` and `Lon` fields), it may be more appropriate to use `geoshow` to display them. You can project latitude and longitude coordinate values to map coordinates by displaying with `geoshow` on a map axes.

Input Arguments

x

Coordinate vector, M-by-N coordinate array, or geolocation array in map coordinates, depending on the syntax. `x` can contain embedded NaNs to delimit individual lines or polygon parts.

y

Coordinate vector, M-by-N coordinate array, or geolocation array in map coordinates, depending on the syntax. `y` can contain embedded NaNs to delimit individual lines or polygon parts.

z

M-by-N array. `z` can contain NaN values.

s

Geographic data structure.

Z

Regular data grid.

R

Referencing matrix or `spatialref.MapRasterReference` object that relates the subscripts of `Z` to map coordinates. If `R` is a `spatialref.MapRasterReference` object with raster interpretation `'postings'`, then `mapshow` does not accept the `'image'` and `'texturemap'` display types.

image

Grayscale, logical, or truecolor image.

A

Indexed image.

cmap

Colormap.

ax

Axes object.

filename

Name of file.

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

SymbolSpec

A structure returned by `makesymbolspec` that specifies the symbolization rules used for vector data. When both `SymbolSpec` and one or more graphics properties are specified, the graphics properties will override any settings in the symbolspec structure.

To change the default symbolization rule for a Name,Value pair in the symbolspec, prefix the word `'Default'` to the graphics property name.

DisplayType

Type of graphic display for the data. You can set any MATLAB Graphics line, patch, image, surface, and contour properties. See the table for links to the MATLAB documentation on these properties.

Data Type	DisplayType	Type of Property
Vector	`'point'`	*line marker* On the MATLAB Line Properties reference page, under Line Property Descriptions, see Marker.
	`'multipoint'`	*line marker* On the MATLAB Line Properties reference page, under Line Property Descriptions, see Marker.
	`'line'` (default)	*line* See the MATLAB Line Properties reference page.
	`'polygon'`	*patch* See the MATLAB Patch Properties reference page.
Image	`'image'` or `'surface'`	*image* or *surface* See the MATLAB Image Properties or Surface Properties reference page.

Data Type	DisplayType	Type of Property
Grid	`'surface'`	*surface* See the MATLAB Surface Properties reference page.
	`'mesh'`	*surface* See the MATLAB Surface Properties reference page.
	`'texturemap'`	*surface* See the MATLAB Surface Properties reference page.
	`'contour'`	*contour* See the MATLAB Contourgroup Properties reference page.

If `DisplayType` is `'texturemap'`, `geoshow` constructs a surface with `ZData` values set to 0.

Set the `DisplayType` to `'image'` if you are using the syntax `mapshow(image, R, ...)`.

When using the `filename` argument, the `DisplayType` parameter is automatically set, according to the following table:

Format	DisplayType
Shapefile	`'point'`, `'line'`, or `'polygon'`
GeoTIFF	`'image'`
TIFF/JPEG/PNG with a world file	`'image'`
ARC ASCII GRID	`'surface'` (can be overridden)
SDTS raster	`'surface'` (can be overridden)

Output Arguments

h

Handle to a MATLAB graphics object or, in the case of polygons, a modified patch object. If a mapstruct or shapefile name is input, `mapshow` returns the handle to an hggroup object with one child per feature in the mapstruct or shapefile. In the case of a polygon mapstruct or shapefile, each child is a modified patch object; otherwise it is a line object.

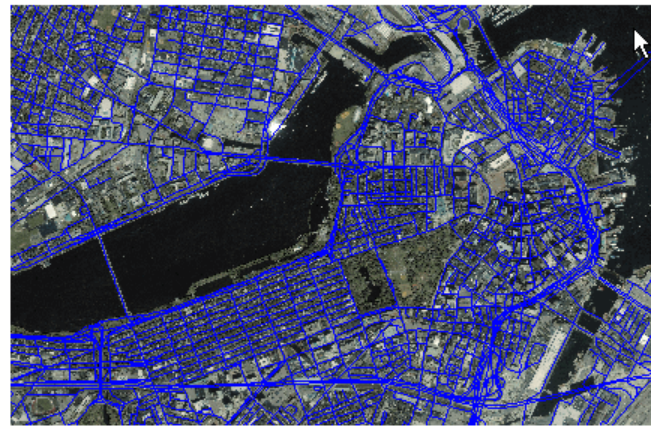
Class Support

Display Type	Supported Class Types
Image	`logical`, `uint8`, `uint16`, and `double`
Surface	`single` and `double`
Texture map	All numeric types and `logical`

Examples

Overlay Boston roads on an orthophoto. Convert Boston road vectors to units of survey feet before overlaying them on the image. (Note that `mapshow` draws a new layer in the axes rather than replacing its contents.)

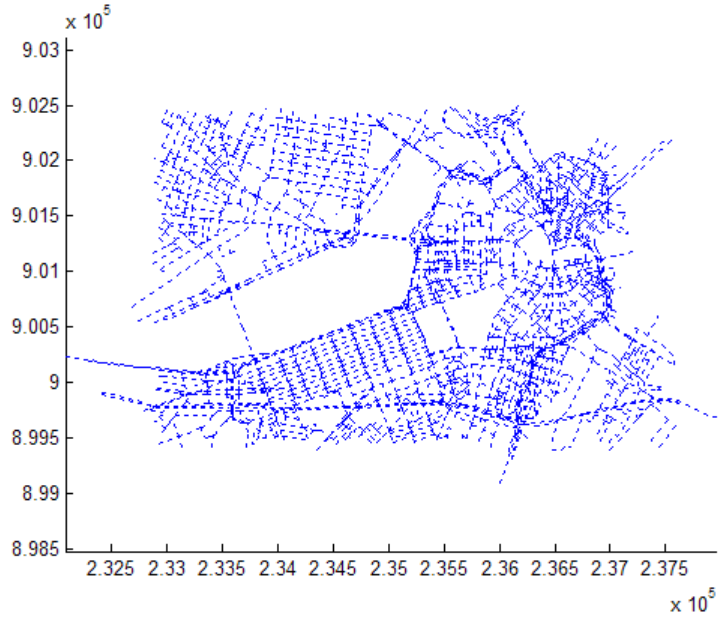
```
figure
mapshow boston.tif
axis image off

% The orthophoto is in survey feet and the roads are in meters.
% Convert the road units to feet before overlaying them.
S = shaperead('boston_roads.shp');
surveyFeetPerMeter = unitsratio('sf','meter');
x = surveyFeetPerMeter * [S.X];
y = surveyFeetPerMeter * [S.Y];
mapshow(x,y)
```



boston.tif image copyright © GeoEye, all rights reserved.

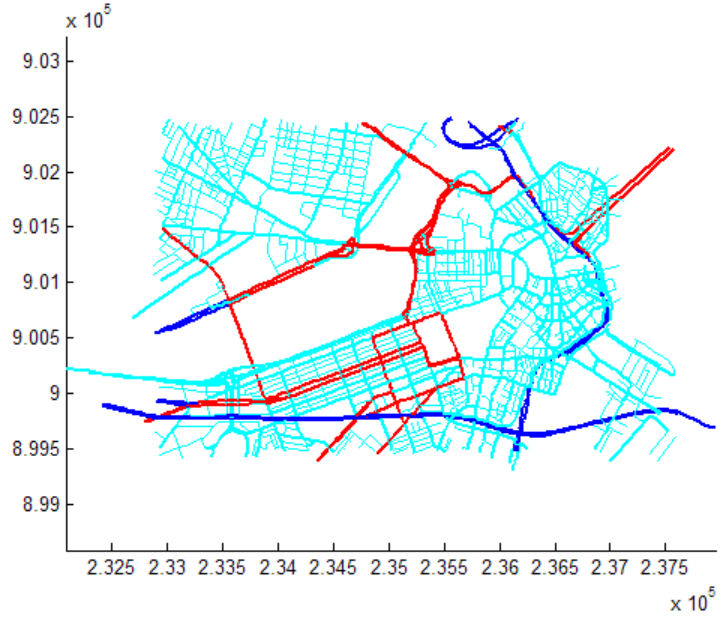
Display Boston roads and change the line style:

```
roads = shaperead('boston_roads.shp');
figure
mapshow(roads,'LineStyle',':');
```



Display the Boston roads shapes using a symbolspec:

```
% Create a SymbolSpec to color local roads:
% (ADMIN_TYPE=0) cyan, state roads (ADMIN_TYPE=3) red.
% Hide very minor roads (CLASS=6).
% Make all roads that are major or larger (CLASS=1-4)
% have a LineWidth of 2.
roadspec = makesymbolspec('Line',...
                          {'ADMIN_TYPE',0,'Color','cyan'}, ...
                          {'ADMIN_TYPE',3,'Color','red'},...
                          {'CLASS',6,'Visible','off'},...
                          {'CLASS',[1 4],'LineWidth',2});
figure
mapshow('boston_roads.shp','SymbolSpec',roadspec);
```

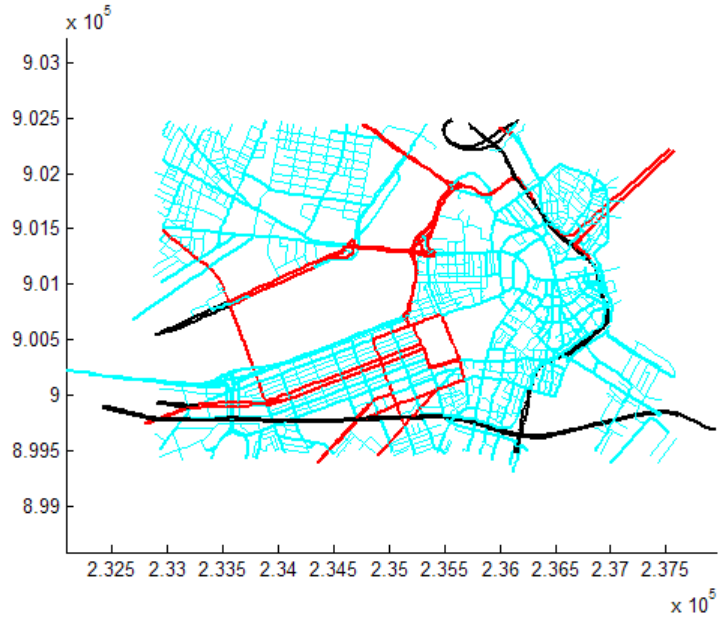


Override default properties in combination with a symbolspec:

```
roadspec = makesymbolspec('Line',...
                          {'Default', 'Color', 'yellow'}, ...
                          {'ADMIN_TYPE',0,'Color','c'}, ...
                          {'ADMIN_TYPE',3,'Color','r'},...
                          {'CLASS',6,'Visible','off'},...
                          {'CLASS',[1 4],'LineWidth',2});
figure
mapshow('boston_roads.shp', 'Color', 'black', ...
   'SymbolSpec', roadspec);
```

Override default properties of the line with a symbolspec:

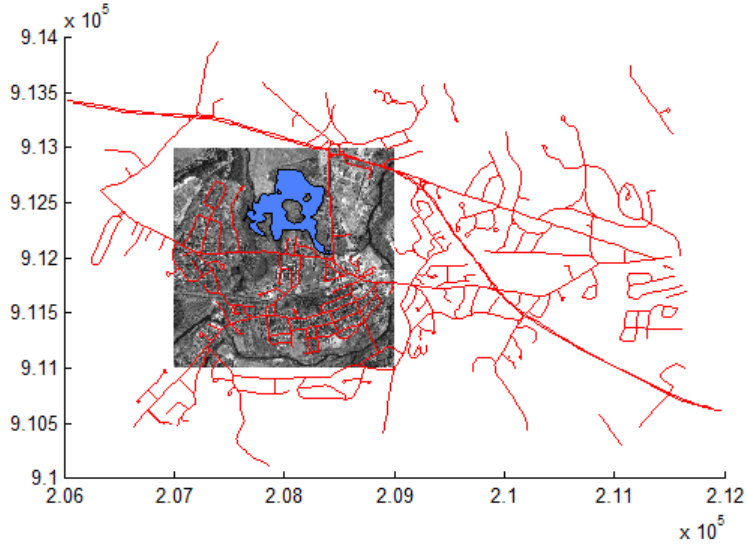
```
roadspec = makesymbolspec('Line',...
                          {'Default', 'Color', 'black'}, ...
                          {'ADMIN_TYPE',0,'Color','c'}, ...
                          {'ADMIN_TYPE',3,'Color','r'},...
                          {'CLASS',6,'Visible','off'},...
                          {'CLASS',[1 4],'LineWidth',2});
figure
mapshow('boston_roads.shp','SymbolSpec',roadspec);
```



Overlay a pond polygon and roads on an orthophoto:

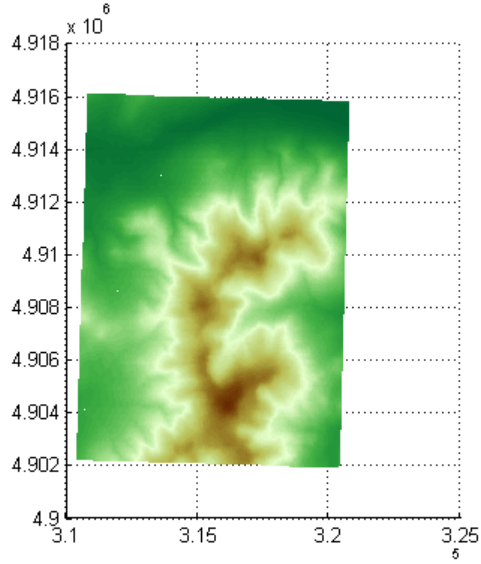
```
% Display an orthophoto of Concord, MA, including a pond with
% three large islands:
[ortho, cmap] = imread('concord_ortho_w.tif');
R = worldfileread('concord_ortho_w.tfw', 'planar', size(ortho));
figure
mapshow(ortho, cmap, R)

% Overlay a polygon representing the same pond
% (feature 14 in the concord_hydro_area shapefile).
% Note that the islands are visible in the orthophoto
% through three "holes" in the pond polygon.
pond = shaperead('concord_hydro_area.shp', 'RecordNumbers', 14);
mapshow(pond, 'FaceColor', [0.3 0.5 1], 'EdgeColor', 'black')
```

```
% Overlay roads in the same figure.
mapshow('concord_roads.shp', 'Color', 'red', 'LineWidth', 1);
```

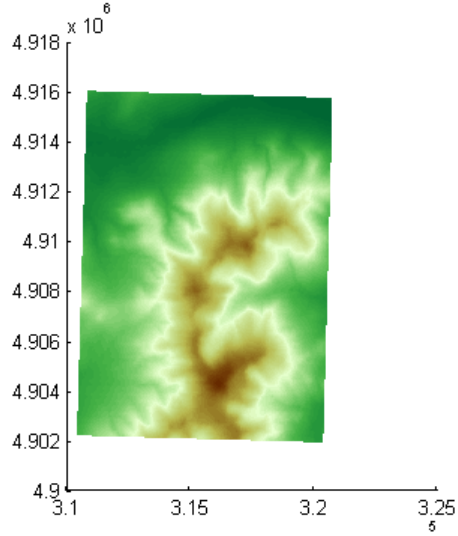


Read and view the Mount Washington SDTS DEM terrain data three different ways:

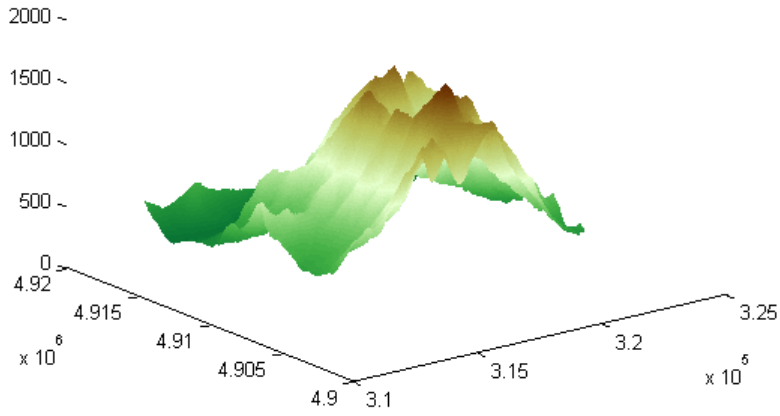
```
[Z, R] = sdtsdemread('9129CATD.DDF');

% View the Mount Washington terrain data as a mesh.
figure
mapshow(Z, R, 'DisplayType', 'mesh');
demcmap(Z)
```




```
% View the Mount Washington terrain data as a surface.
figure
mapshow(Z, R, 'DisplayType', 'surface');
demcmap(Z)
```

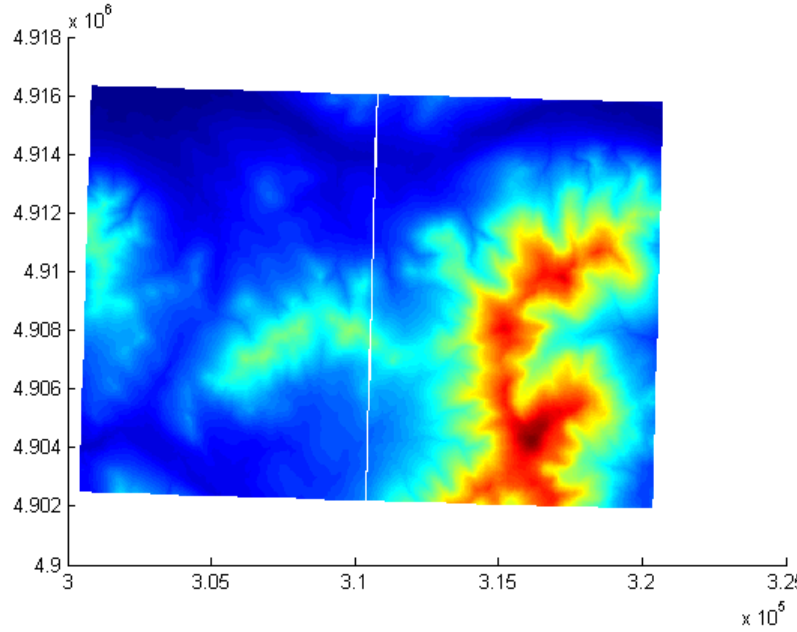



```
% View as a 3-D surface.
view(3);
axis normal
```



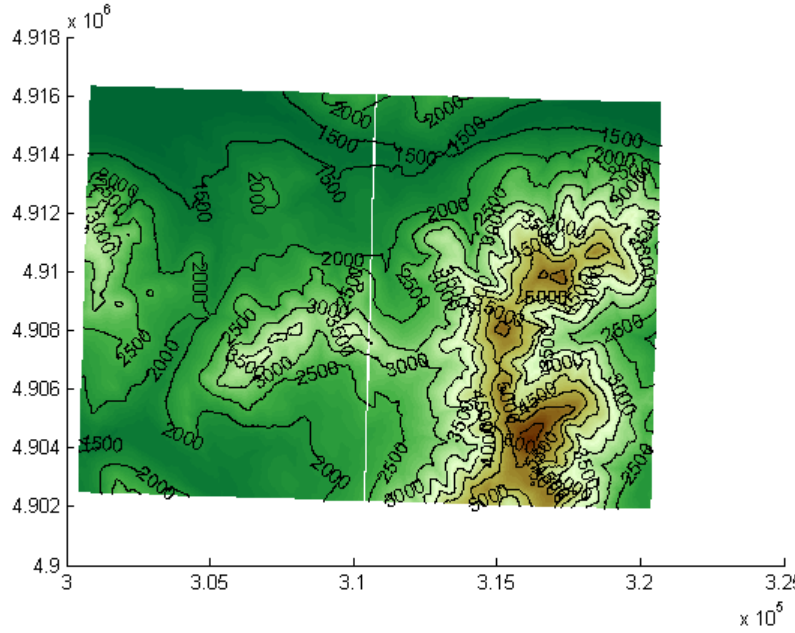
Display the grid and contour lines of Mount Washington and Mount Dartmouth:

```
% Read the terrain data files.
[Z_W, R_W] = arcgridread('MtWashington-ft.grd');
[Z_D, R_D] = arcgridread('MountDartmouth-ft.grd');

% Display the terrain data as a surface.
figure('Renderer', 'zbuffer')
hold on
mapshow(Z_W, R_W, 'DisplayType', 'surface');
mapshow(Z_D, R_D, 'DisplayType', 'surface');
```




```
% Overlay black contour lines with labels onto the surface.
% Set the Z values of the contours to the maximum value of the
% corresponding surface.
```

```
cW = mapshow(Z_W, R_W, 'DisplayType', 'contour', ...
      'LineColor','black', 'ShowText', 'on');
cD = mapshow(Z_D, R_D, 'DisplayType', 'contour', ...
      'LineColor','black', 'ShowText', 'on');
zdatam(get(cW,'Children'), max(Z_W(:)));
zdatam(get(cD,'Children'), max(Z_D(:)));

% Set the colormap appropriate to terrain elevation.
demcmap(Z_W)
```



See Also

geoshow | makesymbolspec | mapview | shaperead

How To

- “Displaying Vector Data with Mapping Toolbox Functions”

Purpose

Trim lines to latitude-longitude quadrangle

Syntax

```
[lat,lon] = maptriml(lat0,lon0,latlim,lonlim)
```

Description

`[lat,lon] = maptriml(lat0,lon0,latlim,lonlim)` returns *filtered* `NaN`-delimited vector map data sets from which all points lying outside the desired latitude and longitude limits have been discarded. These limits are specified by the two-element vectors `latlim` and `lonlim`, which have the form `[south-limit north-limit]` and `[west-limit east-limit]`, respectively.

Examples

Following is a simple example:

```
lat0 = [1:10,9:-1:0]; lon0 = -30:-11;
[lat,lon] = maptriml(lat0,lon0,[3 7],[-29 -12]);
[lat lon]

ans =
   NaN   NaN
     3   -28
     4   -27
     5   -26
     6   -25
     7   -24
   NaN   NaN
     7   -18
     6   -17
     5   -16
     4   -15
     3   -14
   NaN   NaN
```

Notice that trimmed line segment ends have `NaN`s inserted at trim points.

See Also

`maptrimp` | `maptrims`

maptrimp

Purpose

Trim polygons to latitude-longitude quadrangle

Syntax

```
[latTrimmed,lonTrimmed] = maptrimp(lat,lon,latlim,lonlim)
```

Description

`[latTrimmed,lonTrimmed] = maptrimp(lat,lon,latlim,lonlim)` trims the polygons in `lat` and `lon` to the quadrangle specified by `latlim` and `lonlim`. `latlim` and `lonlim` are two-element vectors, defining the latitude and longitude limits respectively. `lat` and `lon` must be vectors that represent valid polygons.

Tips

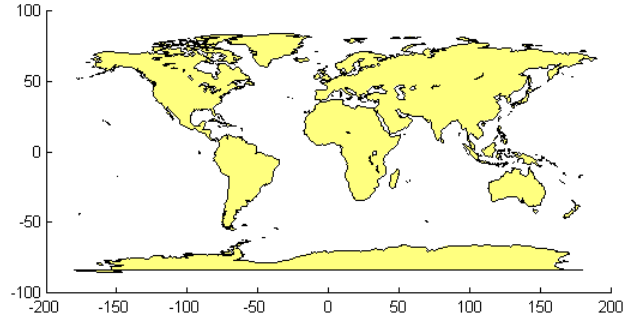
`maptrimp` conditions the longitude limits such that:

- `lonlim(2)` always exceeds `lonlim(1)`
- `lonlim(2)` never exceeds `lonlim(1)` by more than `360`
- `lonlim(1) < 180` or `lonlim(2) > -180`
- Should the quadrangle span the Greenwich meridian, then that meridian appears at longitude = 0.

Examples

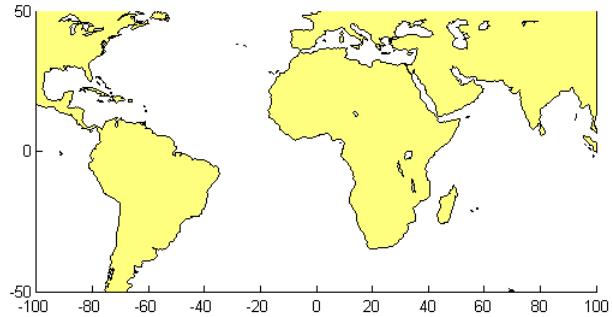
Display a world map of coastline data, trim the dataset to a specific geographic area, and display a map of this trimmed data.

```
coast = load('coast.mat');
figure
mapshow(coast.long, coast.lat, 'DisplayType', 'polygon');
```



Original Map

```
latlim = [-50 50];
lonlim = [-100 50];
[latTrimmed, lonTrimmed] = maptrimp(coast.lat, coast.long, ...
   latlim, lonlim);
figure
mapshow(lonTrimmed, latTrimmed, 'DisplayType', 'polygon');
```



Map with Trimmed Data

See Also

maptriml | maptrims

maptrims

Purpose

Trim regular data grid to latitude-longitude quadrangle

Syntax

```
[Z_trimmed] = maptrims(Z,R,latlim,lonlim)
[Z_trimmed] = maptrims(Z,R,latlim,lonlim,cellDensity)
[Z_trimmed, R_trimmed] = maptrims(...)
```

Description

`[Z_trimmed] = maptrims(Z,R,latlim,lonlim)` trims a regular data grid `Z` to the region specified by `latlim` and `lonlim`. By default, the output grid `Z_trimmed` has the same sample size as the input. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix. If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)` and its `RasterInterpretation` must be `'cells'`.

If `R` is a referencing vector, it must be a 1-by-3 vector with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. `latlim` and `lonlim` are two-element vectors, defining the latitude and longitude limits, respectively. The `latlim` vector has the form:

```
[southern_limit northern_limit]
```

Likewise, the `lonlim` vector has the form:

```
[western_limit eastern_limit]
```

When an individual value in `latlim` or `lonlim` corresponds to a parallel or meridian that runs precisely along cell boundaries, the output grid will extend all the way to that limit. But if a limiting parallel or meridian cuts through a column or row of input cells, then the limit

will be adjusted inward. In other words, the requested limits will be truncated as necessary to avoid partial cells.

`[Z_trimmed] = maptrims(Z,R,latlim,lonlim,cellDensity)` uses the scalar `cellDensity` to reduce the size of the output. If `R` is a referencing vector, then `R(1)` must be evenly divisible by `cellDensity`. If `R` is a referencing matrix, then the inverse of each element in the first two rows (containing "`deltaLat`" and "`deltaLon`") must be evenly divisible by `cellDensity`.

`[Z_trimmed, R_trimmed] = maptrims(...)` returns a referencing vector, matrix, or object for the trimmed data grid. If `R` is a referencing vector, then `R_trimmed` is a referencing vector. If `R` is a referencing matrix, then `R_trimmed` is a referencing matrix. If `R` is a `spatialref.GeoRasterReference` object, then `R_trimmed` is either a `spatialref.GeoRasterReference` object (when `Z_trimmed` is non-empty) or `[]` (when `Z_trimmed` is empty).

Examples

```
load topo
[subgrid,subrefvec] = maptrims(topo,topolegend,...
                               [80.25 85.3],[165.2 170.7])

subgrid =
       -2826       -2810       -2802       -2793
       -2915       -2913       -2905       -2884
       -3192       -3186       -3165       -3122
       -3399       -3324       -3273       -3214

subrefvec =
     1    85   166
```

The upper left corner of the grid might differ slightly from that of the requested region. `maptrims` uses the corner coordinates of the first cell inside the limits.

See Also

`maptriml` | `maptrimp` | `resizem`

mapview

Purpose

Interactive map viewer

Syntax

```
mapview
```

Description

Use the Map Viewer to work with vector, image, and raster data grids in a map coordinate system: load data, pan and zoom on the map, control the map scale of your screen display, control the order, visibility, and symbolization of map layers, annotate your map, and click to learn more about individual vector features. `mapview` complements `mapshow` and `geoshow`, which are for constructing maps in ordinary figure windows in a less interactive, script-oriented way.

`mapview` (with no arguments) starts a new Map Viewer in an empty state. The Map Viewer is a self-contained GUI for viewing geospatial data in map (*x*-*y*) coordinates. For usage information, see the following sections. You can also work through the Map Viewer tutorial, "Tour Boston with the Map Viewer".

Importing Data

The Map Viewer opens with no data loaded and an empty map display window. The first step is to import a data set. Use the options in the **File** menu to select data from a file or from the MATLAB workspace:

Import From File

Use the file browsing dialog to open a file in one of the following formats: Shapefile, GeoTIFF, SDTS DEM, Arc ASCII Grid, TIFF, JPEG, or PNG with world file. This option imports the data into the viewer but does not add it to your workspace.

To view standard-format geodata files provided with the toolbox, set your working folder or navigate the Map Viewer Open dialog to

```
matlabroot/toolbox/map/mapdata
```

Import From Workspace

Images. Use the **Raster Data > Image** import dialog to select a **Referencing matrix or object name** and **Raster data name** for the image from the list of workspace variables. If the image type is truecolor (RGB), specify which band represents the red, green, and blue intensities. (The `RasterInterpretation` of the referencing object must be `'cells'`.)

Data grids. Use the **Raster Data > Grid** import dialog to select X and Y geolocation and data grid array names from the list of workspace variables.

Vector data. Use the **Vector Data > Map coordinates** import dialog to select X and Y variables for map coordinates from the list of workspace variables and identify the type of geometry to be displayed (**Point**, **Line**, or **Polygon**). The X and Y variables can specify multiple line segments or multiple polygons if they contain `NaN`s at matching locations in the coordinate vectors.

Vector geographic data structure. Use the **Vector Data > Geographic data structure** import dialog to select the struct that contains vector map data from the list of workspace variables.

Once you import your first data set, the Map Viewer automatically sets the limits of its map display window to the spatial extent of the imported data.

Working in Map Coordinates

As you move any of the Map Viewer cursors across the map display area, the coordinate readout in the lower left corners shows you the cursor position in map X and Y coordinates.

The Map Viewer requires that all currently viewed data sets possess the same coordinate system and length units. This is likely to be the case for data sets that originated from a common source. If it is not the case, you will need to adjust coordinates before importing data into the Map Viewer.

If some or all of your data is in geographic coordinates, use `projfwd` or `mfwdtran` to project latitudes and longitudes to your desired map coordinate system before you import it. When starting from a different projection, you must first unproject to latitude and longitude using `projinv` or `minvtran`, then reproject with `projfwd` or `mfwdtran`. You might also need to adjust the horizontal datum of your data using, for example, the free GEOTRANS (Geographic Translator) application from the Geospatial Sciences Division of the U.S. National Geospatial-Intelligence Agency (NGA). If you simply need a change of units, multiply by the appropriate conversion factor obtained from `unitsratio`.

`mapview` can also display data in unprojected geographic coordinates, if you consistently substitute longitude for map X and latitude for map Y. Geographic coordinates must be consistently expressed in either degrees or radians (not both at once). When using geographic coordinates, do not specify the viewer's map units (see below); you can only use the Map Viewer's map scale display when working in linear units of length.

Setting Map Units and Scale

If you tell the Map Viewer which length unit you are using, it can calculate an approximate map scale for your onscreen display. Set the map units with either the drop-down menu at the bottom of the display or the **Set Map Units** item in the **Tools** menu.

The scale computed by the Map Viewer is displayed in the window just above the map units drop-down. To change your display scale while keeping the center of the map display fixed, simply edit this text box.

Make sure to format your text in the standard way (`1:`*`N`*, where *`N`* is a positive number such that a distance on the ground is *`N`* times the same distance on your screen, e.g., `1:24000`).

The scale is approximate because it depends on the MATLAB estimate of the size of your screen pixels. It is also approximate if your projection introduces significant distortion. If your data falls in a fairly small area and you use a conformal projection (e.g., UTM with all data in a single zone), the scale will be very consistent across your entire map.

Navigating Your Map

By default, the Map Viewer sets the limits of your map window to match the extent of the first data set that you load. You will probably want to adjust this to see some areas in greater detail.

The Map Viewer provides several tools to control the limits of your map window and the map scale of the data display. Some are familiar from standard MATLAB figure windows.

- **Zoom in**: Drag a box to zoom in on a specific area or click a point to zoom in with that point centered in the map display.
- **Zoom out**: Click a point to zoom out with that point centered in the map display.
- **Pan tool**: Click, hold, and drag to reposition the selected point in the display window, while holding the map scale fixed. Release when you are satisfied with new display limits.
- **Fit to window**: Set the map display to enclose all currently loaded data layers. This is equivalent to selecting **Fit to Window** in the **View** menu.
- **Back to previous view**: Click this button once to return the map scale and display center to their values prior to the most recent zoom, pan, or scale change. Click repeatedly to undo earlier changes. This is equivalent to selecting **Previous View** in the **View** menu.

Another way to zoom in or out while keeping the center of the view fixed at the same map coordinates is to directly edit the map scale box at the bottom of the screen.

Managing Map Layers

Each time you import a set of vectors, an image, or a data grid into the Map Viewer, the new data is stored in a new map layer. The layers form an ordered stack. Each layer is listed as an item in the **Layers** menu, with its position in the menu indicating its position in the stack.

When you import a new layer, the Map Viewer automatically places it at the top of the layer stack. To reposition a layer in the stack, select it in the **Layers** menu, slide right, and select **To Top**, **To Bottom**, **Move Up**, or **Move Down** from the pop-up submenu.

The vector features or raster in a given layer obscure coincident elements of any underlying layers. To control layers that are obscuring one another, you can also toggle layer visibility on and off. Use the item **Visible** in the slide-right menu. Or, simply remove a layer from the Map Viewer via the **Remove** item in the slide-right menu. Remember that even if a layer's visibility is *on*, the layer does not appear if its contents are located completely outside the current display limits or are obscured by another layer.

Symbolizing Vector Features

When point, line, and polygon layers are loaded, the Map Viewer initializes their graphics properties as follows:

Geometry	Properties

Point (line objects)	`LineStyle = 'none`
	`Marker = 'x'`
	`MarkerEdgeColor =` <randomly generated value>
	`MarkerFaceColor = 'none'`

Line (line objects)	`Color =` <randomly generated value>
	`LineStyle = '-'`
	`Marker = 'none'`

Polygon (patch objects)	`EdgeColor = [0 0 0] FaceColor =` <randomly generated value>

To override symbolism defaults for a vector layer, use `makesymbolspec` to create a symbol specification in the workspace. A symbolspec contains a set of rules for setting vector graphics properties based on the values of feature attributes. For instance, if you have a line layer representing roads of various classes (e.g., major highway, secondary road, etc.), you can create a symbolspec to use a different color, line width, or line style for each road class. See the `makesymbolspec` help for examples and to learn how to construct a symbolspec. If you regularly work with data sets sharing a common set of feature attributes, you might want to save one or more symbolspecs in a MAT-file (or save calls to `makesymbolspec` in a MATLAB program file).

Once you have a symbolspec in your workspace, select your vector layer in the **Layers** menu, then slide right and click **Set Symbol Spec**, which opens a dialog box. Use the dialog box to select the symbolspec from your workspace.

Getting Information About Vector Features

The **Datatip** tool and the **Info** tool provide different ways to check the attributes of vector features that you select graphically. Before using either tool you must designate one of your vector layers as *active*. (The default active layer is the first one that you imported.) Either use the **Active Layer** drop-down menu at the bottom of your screen or select the layer in the **Layers** menu, slide right, and select **Active**. Having a designated active layer ensures that when you click a feature you don't inadvertently select an overlapping feature from a different layer.

- **Datatip tool**: The **Datatip** tool displays a feature attribute in a text label each time you click a vector feature. By default the attribute is the first one in the layer's attribute list. To change which attribute is used, select the layer in the **Layers** menu, slide right, and click `Set Layer Attribute`. In the dialog that follows, select a different attribute, or `Index`. If you choose `Index`, the Map Viewer displays the one-based index value corresponding to a given feature—based on its position in the input file or workspace array. To remove a text label, right-click it and choose **Delete datatip** from the context menu. Or choose **Delete all datatips** from the context menu or the **Tools** menu.
- **Info tool**: The **Info** tool opens a separate text window each time you click a vector feature. The window displays all the attribute names and values for that feature, in contrast to the **Datatip** tool, which displays only the value of a single attribute. If you need to compare two or more features, simply click each one and view the info windows together. Use its close button to close an info window when you're done with it, or choose **Close All Info Windows** from the **Tools** menu.

Annotating Your Map

Use the **text**, **line**, or **arrow** annotation tools to mark and highlight points of interest on your map, or select the corresponding items in the **Insert** menu. Note that to insert an additional object of the same type,

you must reselect the appropriate tool. In addition, the **Insert** menu allows you to insert axis labels and a title. Use the **Select annotations** tool and **Edit** menu to modify or remove your annotations. The Map Viewer manages annotations separately from data layers; annotations always stay on top. Note that annotations cannot be saved as graphic objects, although you can export maps containing annotations to an image format as described below.

Creating and Using Additional Views

Use **New View** on the **File** menu to create an additional Map Viewer window linked to an existing window. Consider using an additional window when you want to see your map at different scales at the same time (e.g., a detailed view plus an overview), or when you want to simultaneously see different areas of the map at large scale. You can create as many additional windows as you need, and close them when you want. Your `mapview` session ends when you close the last window.

Options for creating a new viewer window include: **Duplicate Current View**, **Full Extent**, **Full Extent of Active Layer**, and **Selected Area**. Click and drag with the **Select area** tool to define a selected area.

A new viewer window differs from existing windows mainly in terms of the visible map extent and scale (it also omits annotations and any labels you added with the datatip tool). You will see the same layers in the same order with the same settings (including the active layer). Updates to layers (insertion/removal, order, visibility, label attribute, and symbolization) in one viewer window are propagated automatically to all the windows with which it is linked. Updates to annotations and datatip labels are not propagated between viewers. If you need two different layer configurations in different windows, launch a second `mapview` from the command line instead of creating an additional window. The views it contains will not be linked to previous ones.

Exporting Your Map

The Map Viewer allows you to export all or part of your map for use in a publication or on a Web page. Use **File > Save As Raster Map** to export an image of either the current display extent or an area outlined with the **Select area** tool. Select a format (PNG, TIFF, JPEG) from the drop-down menu in the export dialog. For maps including vector layers, PNG (Portable Network Graphics) is often the best choice. This format

provides excellent quality, good compression, and is well supported by modern Web browsers. The export process automatically creates a world file (ending with suffix `tfw`, `jgw`, or `pgw`) as well; the pair of files constitute a georeferenced image that itself can be displayed with `mapview`, `mapshow`, and many external GIS packages.

See Also

`arcgridread` | `geoshow` | `geotiffread` | `makesymbolspec` | `mapshow` | `sdtsdemread` | `shaperead` | `updategeostruct` | `worldfileread`

mdistort

Purpose

Display contours of constant map distortion

Syntax

```
mdistort
mdistort off
mdistort(parameter)
mdistort parameter
mdistort(parameter,levels)
mdistort(parameter,levels,gsize)
h = mdistort(...)
```

Description

`mdistort`, with no input arguments, toggles the display of contours of projection-induced distortion on the current map axes. The magnitude of the distortion is reported in percent.

`mdistort off` removes the contours.

`mdistort(parameter)` or `mdistort parameter` displays contours of distortion for the specified parameter. Recognized *`parameter`* strings are `'area'`, `'angles'` for the maximum angular distortion of right angles, `'scale'` or `'maxscale'` for the maximum scale, `'minscale'` for the minimum scale, `'parscale'` for scale along the parallels, `'merscale'` for scale along the meridians, and `'scaleratio'` for the ratio of maximum and minimum scale. If omitted, the `'maxscale'` parameter is displayed. All parameters are displayed as percent distortion except angles, which are displayed in degrees.

`mdistort(parameter,levels)` specifies the levels for which the contours are drawn. `levels` is a vector of values as used by `contour`. If empty, the default levels are used.

`mdistort(parameter,levels,gsize)` controls the size of the underlying graticule matrix used to compute the contours. `gsize` is a two-element vector containing the number of rows and columns. If omitted, the default Mapping Toolbox graticule size of `[50 100]` is assumed.

`h = mdistort(...)` returns a handle to the contourgroup object containing the contours and text.

Background

Map projections inevitably introduce distortions in the shape and size of objects as they are transformed from three-dimensional spherical coordinates to two-dimensional Cartesian coordinates. The amount and type of distortion vary between projections, over the projection, and with the selection of projection parameters such as standard parallels. This function provides a quantitative graphical display of distortion parameters.

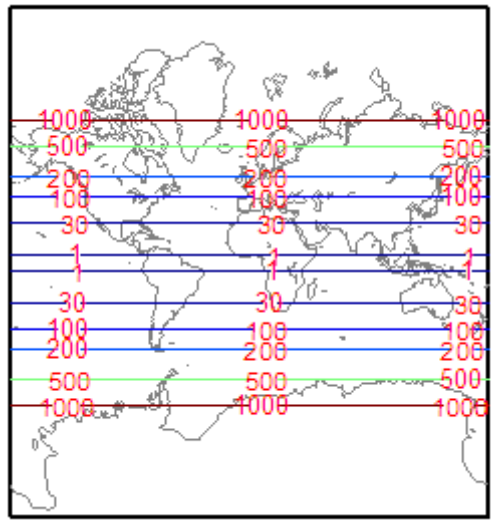
`mdistort` is not intended for use with UTM. Distortion is minimal within a given UTM zone. `mdistort` issues a warning if a UTM projection is encountered.

Examples

Example 1

Note the extreme area distortion of the Mercator projection. This makes it ill-suited for global displays.

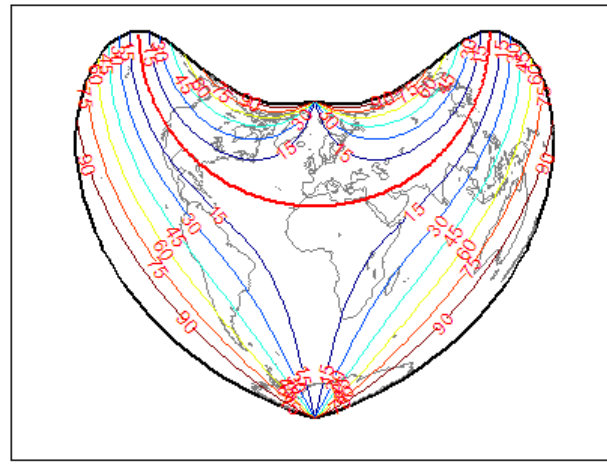
```
figure
axesm mercator
load coast
framem;
plotm(lat, long,'color',.5*[1 1 1])
mdistort('area', [1 30 100 200 500 1000])
```



Example 2

The lines of zero distortion for the Bonne projection follow the central meridian and the standard parallel.

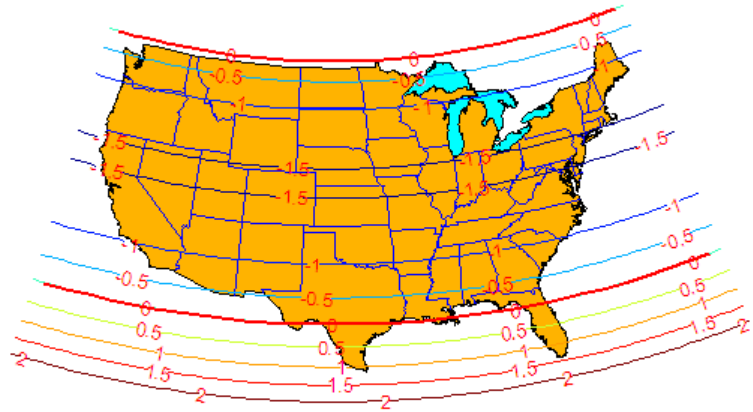
```
figure
axesm bonne
load coast
framem;plotm(lat, long,'color',.5*[1 1 1])
mdistort('angles', 0:15:90)
parallelui
```



Example 3

An equidistant conic projection with properly chosen parallels can map the conterminous United States with less than 1.5% distortion.

```
figure
usamap conus
load conus
patchm(uslat, uslon, [1 0.7 0])
plotm(statelat, statelon)
patchm(gtlakelat, gtlakelon, 'cyan')
framem off; gridm off; mlabel off; plabel off
mdistort('parscale', -2:.5:2)
parallelui
```



Tips

`mdistort` can help in the placement of standard parallels for projections. Standard parallels are generally placed to minimize distortion over the region of interest. The default parallel locations might not be appropriate for maps of smaller regions. By using `mdistort` and `parallelui`, you can immediately see how the movement of parallels reduces distortion.

See Also

`tissot` | `distortcalc` | `vfwdtran`

Purpose

Mean location of geographic coordinates

Syntax

```
[latmean,lonmean] = meanm(lat,lon)
[latmean,lonmean] = meanm(lat,lon,units)
[latmean,lonmean] = meanm(lat,lon,ellipsoid)
```

Description

`[latmean,lonmean] = meanm(lat,lon)` returns row vectors of the geographic mean positions of the columns of the input latitude and longitude points.

`[latmean,lonmean] = meanm(lat,lon,units)` indicates the angular units of the data. When the standard angle string *`units`* is omitted, `'degrees'` is assumed.

`[latmean,lonmean] = meanm(lat,lon,ellipsoid)` specifies the shape of the Earth using `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The default ellipsoid model is a spherical Earth, which is sufficient for most applications.

If a single output argument is used, then `geomeans = [latmean,longmean]`. This is particularly useful if the original `lat` and `lon` inputs are column vectors.

Background

Finding the mean position of geographic points is more complicated than simply averaging the latitudes and longitudes. `meanm` determines mean position through three-dimensional vector addition. See "Geographic Statistics" in the *Mapping Toolbox User's Guide*.

Examples

Create random latitude and longitude matrices:

```
lat = rand(3)

lat =
    0.9501    0.4860    0.4565
    0.2311    0.8913    0.0185
    0.6068    0.7621    0.8214
```

```
lon = rand(3)

lon =
    0.4447    0.9218    0.4057
    0.6154    0.7382    0.9355
    0.7919    0.1763    0.9169

[latmean,lonmean] = meanm(lat,lon,'radians')

latmean =
    0.6004    0.7395    0.4448
lonmean =
    0.6347    0.6324    0.7478
```

See Also

filterm | hista | histr | stdist | stdm

Purpose

Ellipsoidal distance along meridian

Syntax

```
s = meridianarc(phi1,phi2,ellipsoid)
```

Description

`s = meridianarc(phi1,phi2,ellipsoid)` calculates the (signed) distance `s` between latitudes `phi1` and `phi2` along a meridian on the ellipsoid defined by `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. Latitudes `phi1` and `phi2` are in radians. The distance `s` has the same units as the semimajor axis of the ellipsoid. If `phi2` is less than `phi1`, `s` is negative.

See Also

`meridianfwd`

meridianfwd

Purpose

Reckon position along meridian

Syntax

```
phi2 = meridianfwd(phi1,s,ellipsoid)
```

Description

`phi2 = meridianfwd(phi1,s,ellipsoid)` determines the geodetic latitude `phi2` reached by starting at geodetic latitude `phi1` and traveling distance `s` north (positive `s`) or south (negative `s`) along a meridian on the specified `ellipsoid`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. Latitudes `phi1` and `phi2` are in radians, and `s` has the same units as the semimajor axis of the ellipsoid.

See Also

`meridianarc`

Purpose

Construct map graticule for surface object display

Syntax

```
[lat, lon] = meshgrat(Z, R)
[lat, lon] = meshgrat(Z, R, gratsize)
[lat, lon] = meshgrat(lat, lon)
[lat, lon] = meshgrat(latlim, lonlim, gratsize)
[lat, lon] = meshgrat(lat, lon, angleunits)
[lat, lon] = meshgrat(latlim, lonlim, angleunits)
[lat, lon] = meshgrat(latlim, lonlim, gratsize, angleunits)
```

Description

`[lat, lon] = meshgrat(Z, R)` constructs a graticule for use in displaying a regular data grid, `Z`. In typical usage, a latitude-longitude graticule is projected, and the grid is warped to the graticule using MATLAB graphics functions. In this two-argument calling form, the graticule size is equal to the size of `Z`. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel.

`[lat, lon] = meshgrat(Z, R, gratsize)` produces a graticule of size `gratsize`. `gratsize` is a two-element vector of the form `[number_of_parallels number_of_meridians]`. If `gratsize = []`, then the graticule returned has the default size 50-by-100. (But if `gratsize` is omitted, a graticule of the same size as `Z` is returned.) A

finer graticule uses larger arrays and takes more memory and time but produces a higher fidelity map.

`[lat, lon] = meshgrat(lat, lon)` takes the vectors `lat` and `lon` and returns graticule arrays of size `numel(lat)-by-numel(lon)`. In this form, `meshgrat` is similar to the MATLAB function `meshgrid`.

`[lat, lon] = meshgrat(latlim, lonlim, gratsize)` returns a graticule mesh of size `gratsize` that covers the geographic limits defined by the two-element vectors `latlim` and `lonlim`.

`[lat, lon] = meshgrat(lat, lon, angleunits)`, `[lat, lon] = meshgrat(latlim, lonlim, angleunits)`, and `[lat, lon] = meshgrat(latlim, lonlim, gratsize, angleunits)` use the string *`angleunits`* to specify the angle units of the inputs and outputs. The string *`angleunits`* can be either `'degrees'` (the default) or `'radians'`.

The graticule mesh is a grid of points that are projected on a map axes and to which surface map objects are warped. The fineness, or resolution, of this grid determines the quality of the projection and the speed of plotting. There is no hard and fast rule for sufficient graticule resolution, but in general, cylindrical projections need very few graticules in the longitudinal direction, while complex curve-generating projections require more.

Examples

Make a (coarse) graticule for the entire world:

```
latlim = [-90 90];
lonlim = [-180 180];
[lat,lon] = meshgrat(latlim,lonlim,[3 6])

lat =
  -90.0000  -90.0000  -90.0000  -90.0000  -90.0000  -90.0000
         0         0         0         0         0         0
   90.0000   90.0000   90.0000   90.0000   90.0000   90.0000
lon =
 -180.0000 -108.0000  -36.0000   36.0000  108.0000  180.0000
 -180.0000 -108.0000  -36.0000   36.0000  108.0000  180.0000
```

```
  -180.0000 -108.0000  -36.0000   36.0000  108.0000  180.0000
```

These paired coordinates are the graticule vertices, which are projected according to the requirements of the desired map projection. Then a surface object like the `topo` map can be warped to the grid.

See Also

`meshgrid` | `meshm` | `surfacem` | `surfm`

meshlsrm

Purpose

3-D lighted shaded relief of regular data grid

Syntax

```
meshlsrm(Z,R)
meshlsrm(Z,R,[azim elev])
meshlsrm(Z,R,[azim elev],cmap)
meshlsrm(Z,R,[azim elev],cmap,clim)
h = meshlsrm(...)
```

Description

`meshlsrm(Z,R)` displays the regular data grid `Z` colored according to elevation and surface slopes. `R` can be a referencing vector, a referencing matrix, or a `spatialref.GeoRasterReference` object.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. By default, shading is based on a light to the east (90 deg.) at an elevation of 45 degrees. Also by default, the colormap is constructed from 16 colors and 16 grays. Lighting is applied before the data is projected. The current axes must have a valid map projection definition.

`meshlsrm(Z,R,[azim elev])` displays the regular data grid `Z` with the light coming from the specified azimuth and elevation. Angles are specified in degrees, with the azimuth measured clockwise from North, and elevation up from the zero plane of the surface.

`meshlsrm(Z,R,[azim elev],cmap)` displays the regular data grid `Z` using the specified colormap. The number of grayscales is chosen to

keep the size of the shaded colormap below 256. If the vector of `azimuth` and `elevation` is empty, the default locations are used. Color axis limits are computed from the data.

`meshlsrm(Z,R,[azim elev],cmap,clim)` uses the provided color axis limits, which by default are computed from the data.

`h = meshlsrm(...)` returns the handle to the surface drawn.

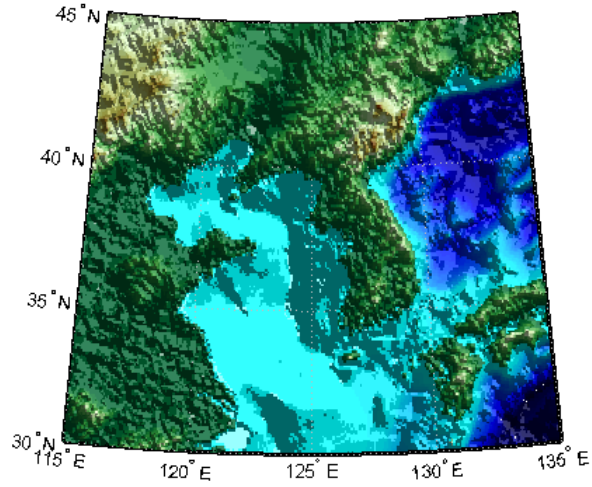
Tips

This function effectively multiplies two colormaps, one with color based on elevation, the other with a grayscale based on the slope of the surface, to create a new colormap. This produces an effect similar to using a light on a surface, but with all of the visible colors actually in the colormap. Lighting calculations are performed on the unprojected data.

Examples

Create a new colormap using `demcmap`, with white colors for the sea and default colors for land. Use this colormap for a lighted shaded relief map of the world.

```
korea = load('korea.mat');
Z = korea.map;
R = georasterref('RasterSize', size(Z), ...
  'Latlim', [30 45], 'Lonlim', [115 135]);
worldmap(Z, R)
meshlsrm(Z, R, [45, 65])
```



See Also

meshgrat | meshm | pcolorm | surfacem | surflm | surflsrm

Purpose

Project regular data grid on map axes

Syntax

```
meshm(Z, R)
meshm(Z, R, gratsize)
meshm(Z, R, gratsize, alt)
meshm(..., param1, val1, param2, val2, ...)
H = meshm(...)
```

Description

`meshm(Z, R)` will display the regular data grid `Z` warped to the default projection graticule. `R` can be a referencing vector, a referencing matrix, or a `spatialref.GeoRasterReference` object.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. The current axes must have a valid map projection definition.

`meshm(Z, R, gratsize)` displays a regular data grid warped to a graticule mesh defined by the 1-by-2 vector `gratsize`. `gratsize(1)` indicates the number of lines of constant latitude (parallels) in the graticule, and `gratsize(2)` indicates the number of lines of constant longitude (meridians).

`meshm(Z, R, gratsize, alt)` displays the regular surface map at the altitude specified by `alt`. If `alt` is a scalar, then the grid is drawn in the z = `alt` plane. If `alt` is a matrix, then `size(alt)` must equal `gratsize`,

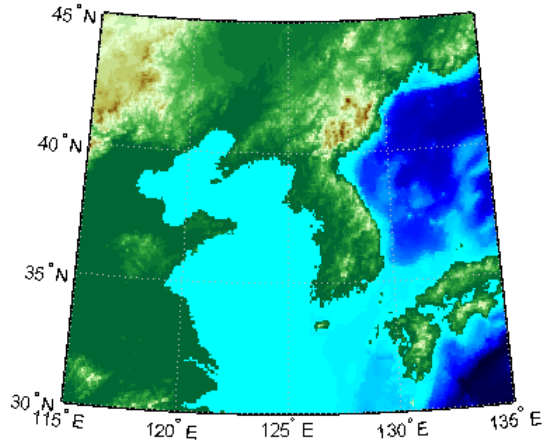
and the graticule mesh is drawn at the altitudes specified by `alt`. If the default graticule is desired, set `gratsize = []`.

`meshm(..., param1, val1, param2, val2, ...)` uses optional parameter name-value pairs to control the properties of the surface object constructed by `meshm`. (If data is placed in the `UserData` property of the surface, then the projection of this object can not be altered once displayed.)

`H = meshm(...)` returns the handle to the surface drawn.

Examples

```
korea = load('korea.mat');
Z = korea.map;
R = georasterref('RasterSize', size(Z), ...
  'Latlim', [30 45], 'Lonlim', [115 135]);
worldmap(Z, R)
meshm(Z, R)
demcmap(Z)
```



See Also

`geoshow` | `mapshow` | `meshgrat` | `pcolorm` | `surfacem` | `surfm`

Purpose

Project geographic features to map coordinates

Syntax

```
[x,y] = mfwdtran(lat,lon)
[x,y,z] = mfwdtran(lat,lon,alt)
[...] = mfwdtran(mstruct,...)
```

Description

`[x,y] = mfwdtran(lat,lon)` applies the forward transformation defined by the map projection in the current map axes. You can use this function to convert point locations and line and polygon vertices given in latitudes and longitudes to a planar, projected map coordinate system.

`[x,y,z] = mfwdtran(lat,lon,alt)` applies the forward projection to 3-D input, resulting in 3-D output. If the input `alt` is empty or omitted, then `alt` = 0 is assumed.

`[...] = mfwdtran(mstruct,...)` requires a valid map projection structure as the first argument. In this case, no map axes is needed.

Examples

The following latitude and longitude data for the District of Columbia is obtained from the `usastatelo` shapefile:

```
dc = shaperead('usastatelo', 'UseGeoCoords', true,...
    'Selector',{@(name) strcmpi(name,'District of Columbia'),...
    'Name'});
lat = [dc.Lat]';
lon = [dc.Lon]';
[lat lon]

ans =
   38.9000  -77.0700
   38.9500  -77.1200
   39.0000  -77.0300
   38.9000  -76.9000
   38.7800  -77.0300
   38.8000  -77.0200
   38.8700  -77.0200
   38.9000  -77.0700
   38.9000  -77.0500
```

```
   38.9000  -77.0700
       NaN       NaN
```

Before projecting the data, it is necessary to define projection parameters. You can do this with the `axesm` function or with the `defaultm` function:

```
mstruct = defaultm('mercator');
mstruct.origin = [38.89 -77.04 0];
mstruct = defaultm(mstruct);
```

Now that the projection parameters have been set, transform the District of Columbia data into map coordinates using the Mercator projection:

```
[x,y] = mfwdtran(mstruct,lat,lon);
[x y]

ans =
   -0.0004    0.0002
   -0.0011    0.0010
    0.0001    0.0019
    0.0019    0.0002
    0.0001   -0.0019
    0.0003   -0.0016
    0.0003   -0.0003
   -0.0004    0.0002
   -0.0001    0.0002
   -0.0004    0.0002
       NaN       NaN
```

See Also

`defaultm` | `gcm` | `minvtran` | `projfwd` | `projinv` | `vfwdtran` | `vinvtran`

Purpose

Semiminor axis of ellipse

Syntax

```
b = minaxis(semimajor,e)
b = minaxis(vec)
```

Description

`b = minaxis(semimajor,e)` computes the semiminor axis of an ellipse (or ellipsoid of revolution) given the semimajor axis and eccentricity. The input data can be scalar or matrices of equal dimensions.

`b = minaxis(vec)` assumes a 2 element vector (`vec`) is supplied, where `vec` = [`semimajor`, `e`].

See Also

`axes2ecc` | `flat2ecc` | `majaxis` | `n2ecc`

minvtran

Purpose

Unproject features from map to geographic coordinates

Syntax

```
[lat,lon] = minvtran(x,y)
[lat,lon,alt] = minvtran(x,y,z)
[...] = minvtran(mstruct,...)
```

Description

`[lat,lon] = minvtran(x,y)` applies the inverse transformation defined by the map projection in the current map axes. Using `minvtran`, you can convert point locations and line and polygon vertices in a planar, projected map coordinate system to latitudes and longitudes.

`[lat,lon,alt] = minvtran(x,y,z)` applies the inverse projection to 3-D input, resulting in 3-D output. If the input `Z` is empty or omitted, then `Z = 0` is assumed.

`[...] = minvtran(mstruct,...)` takes a valid map projection structure as the first argument. In this case, no map axes is needed.

Examples

Before using any transformation functions, it is necessary to create a map projection structure. You can do this with `axesm` or the `defaultm` function:

```
mstruct = defaultm('mercator');
mstruct.origin = [38.89 -77.04 0];
mstruct = defaultm(mstruct);
```

The following latitude and longitude data for the District of Columbia is obtained from the `usastatelo` shapefile:

```
dc = shaperead('usastatelo', 'UseGeoCoords', true,...
     'Selector',{@(name) strcmpi(name,'District of Columbia'),...
     'Name'});
lat = [dc.Lat]';
lon = [dc.Lon]';
[lat lon]

ans =
   38.9000  -77.0700
```

```
   38.9500  -77.1200
   39.0000  -77.0300
   38.9000  -76.9000
   38.7800  -77.0300
   38.8000  -77.0200
   38.8700  -77.0200
   38.9000  -77.0700
   38.9000  -77.0500
   38.9000  -77.0700
       NaN       NaN
```

This data can be projected into Cartesian coordinates of the Mercator projection using the `mfwdtran` function:

```
[x,y] = mfwdtran(mstruct,lat,lon);
[x y]

ans =
   -0.0004    0.0002
   -0.0011    0.0010
    0.0001    0.0019
    0.0019    0.0002
    0.0001   -0.0019
    0.0003   -0.0016
    0.0003   -0.0003
   -0.0004    0.0002
   -0.0001    0.0002
   -0.0004    0.0002
       NaN       NaN
```

To transform the projected *x-y* data back into the unprojected geographic system, use the `minvtran` function:

```
[lat2,lon2] = minvtran(mstruct,x,y);
[lat2 lon2]

ans =
   38.9000  -77.0700
```

```
   38.9500  -77.1200
   39.0000  -77.0300
   38.9000  -76.9000
   38.7800  -77.0300
   38.8000  -77.0200
   38.8700  -77.0200
   38.9000  -77.0700
   38.9000  -77.0500
   38.9000  -77.0700
       NaN       NaN
```

See Also

axesm | defaultm | gcm | mfwdtran | projfwd | projinv | vfwdtran | vinvtran

Purpose

Toggle and control display of meridian labels

Syntax

```
mlabel
mlabel('on')
mlabel('off')
mlabel('reset')
mlabel(parallel)
mlabel(MapAxesPropertyName,PropertyValue,...)
```

Description

`mlabel` toggles the visibility of meridian labeling on the current map axes.

`mlabel('on')` sets the visibility of meridian labels to `'on'`.

`mlabel('off')` sets the visibility of meridian labels to `'off'`.

`mlabel('reset')` resets the displayed meridian labels using the currently defined meridian label properties.

`mlabel(parallel)` sets the value of the `MLabelParallel` property of the map axes to the value of `parallel`. This determines the parallel upon which the labels are placed (see `axesm`). The options for `parallel` are a scalar latitude or the strings `'north'`, `'south'`, or `'equator'`.

`mlabel(`*`MapAxesPropertyName`*`,PropertyValue,...)` allows paired map axes' property names and property values to be passed in. For a complete description of map axes properties, see the `axesm` reference page in this guide.

Meridian label handles can be returned in `h` if desired.

See Also

`axesm` | `mlabelzero22pi` | `plabel` | `setm`

mlabelzero22pi

Purpose

Convert meridian labels to 0-360 degree range

Syntax

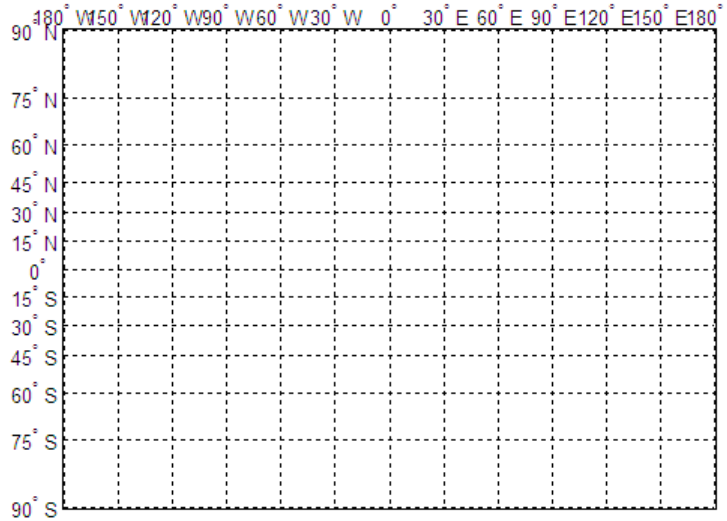
```
mlabelzero22pi
```

Description

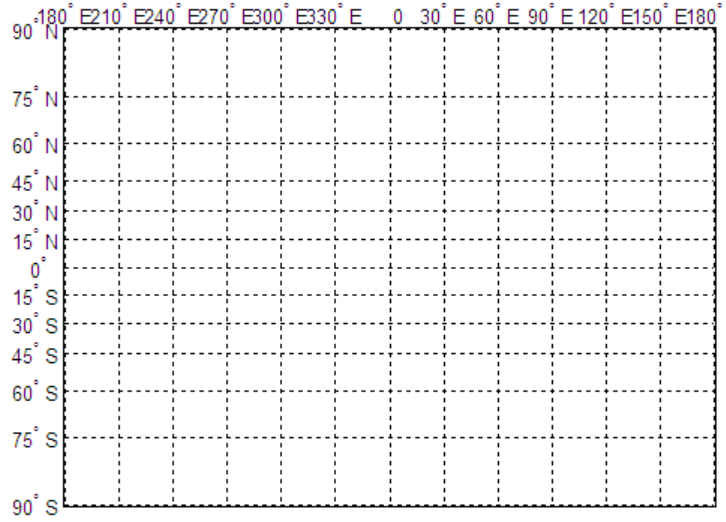
`mlabelzero22pi` displays longitude labels in the range of 0 to 360 degrees east of the prime meridian.

Examples

```
% create a map
figure('color','w'); axesm('miller','grid','on'); tightmap;
mlabel on; plabel on
```




```
% Display longitude labels in the range of 0 to 360 degrees
mlabelzero22pi
```



See Also

`mlabel`

n2ecc

Purpose

Eccentricity of ellipse from third flattening

Syntax

Description

ecc = n2ecc(n) computes the eccentricity of an ellipse (or ellipsoid of revolution) given the parameter n (the "third flattening"). n is defined as (a-b)/(a+b), where a is the semimajor axis and b is the semiminor axis. Except when the input has 2 columns (or is a row vector), each element is assumed to be a third flattening and the output ecc has the same size as n.

ecc = n2ecc(n), where n has two columns (or is a row vector), assumes that the second column is a third flattening, and a column vector is returned.

See Also

`axes2ecc | ecc2n`

Purpose

Determine names of valid graphics objects

Syntax

```
objects = namem
objects = namem(handles)
```

Description

`objects = namem` returns the object names for all objects on the current axes. The object name is defined as its tag, if the object `Tag` property is supplied. Otherwise, it is the object `Type`. Duplicate object names are removed from the output string matrix.

`objects = namem(handles)` returns the object names for the objects specified by the input `handles`.

The names returned are either set at object creation or defined by the user with the `tagm` function.

See Also

`clma` | `clmo` | `handlem` | `hidem` | `showm` | `tagm`

nanclip

Purpose

Clip vector data with NaNs at specified pen-down locations

Syntax

```
dataout = nanclip(datain)
dataout = nanclip(datain,pendowncmd)
```

Description

`dataout = nanclip(datain)` and `dataout = nanclip(datain,pendowncmd)` return the pen-down delimited data in the matrix `datain` as `NaN`-delimited data in `dataout`. When the first column of `datain` equals `pendowncmd`, a segment is started and a `NaN` is inserted in all columns of `dataout`. The default `pendowncmd` is `-1`.

Pen-down delimited data is a matrix with a first column consisting of pen commands. At the beginning of each segment in the data, this first column has an entry corresponding to a pen-down command. Other entries indicate that the segment is continuing. `NaN`-delimited data consists of columns of data, each segment of which ends in a `NaN` in every data column. Since there is no pen command column, the `NaN`-delimited format can represent the same data in one fewer columns; the remaining columns have more entries, one for each `NaN` (that is, for each segment).

Examples

```
datain = [-1 45 67; 0 23 54; 0 28 97; -1 47 89; 0 56 12]

datain =
    -1    45    67          % Begin first segment
     0    23    54
     0    28    97
    -1    47    89          % Begin second segment
     0    56    12

dataout = nanclip(datain)

dataout =
    45    67
    23    54
    28    97
   NaN   NaN               % End first segment
    47    89
```

```
    56    12
   NaN   NaN                % End second segment
```

See Also

spcread

nanm

Purpose

Construct regular data grid of NaNs

Syntax

```
[Z,refvec] = nanm(latlim,lonlim,scale)
```

Description

`[Z,refvec] = nanm(latlim,lonlim,scale)` returns a regular data grid consisting entirely of `NaN`s and a three-element referencing vector for the returned `Z`. The two-element vectors `latlim` and `lonlim` define the latitude and longitude limits of the geographic region. They should be of the form `[south north]` and `[west east]`, respectively. The scalar `scale` specifies the number of rows and columns per degree of latitude and longitude.

Examples

```
[Z,refvec] = nanm([46,51],[-79,-75],1)

Z =
   NaN   NaN   NaN   NaN
   NaN   NaN   NaN   NaN
   NaN   NaN   NaN   NaN
   NaN   NaN   NaN   NaN
   NaN   NaN   NaN   NaN
refvec =
     1    51   -79
```

See Also

`limitm` | `onem` | `sizem` | `spzerom` | `zerom`

Purpose

Mercator-based navigational fix

Syntax

```
[latfix,lonfix] = navfix(lat,long,az)
[latfix,lonfix] = navfix(lat,long,range,casetype)
[latfix,lonfix] = navfix(lat,long,az_range,casetype)
[latfix,lonfix] = navfix(lat,long,az_range,casetype,drlat,
   drlon)
```

Description

`[latfix,lonfix] = navfix(lat,long,az)` returns the intersection points of rhumb lines drawn parallel to the observed bearings, `az`, of the landmarks located at the points `lat` and `long` and passing through these points. One bearing is required for each landmark. Each possible pairing of the n landmarks generates one intersection, so the total number of resulting intersection points is the combinatorial *n choose 2*. The calculation time therefore grows rapidly with n.

`[latfix,lonfix] = navfix(lat,long,range,casetype)` returns the intersection points of Mercator projection circles with radii defined by `range`, centered on the landmarks located at the points `lat` and `long`. One range value is required for each landmark. Each possible pairing of the *n* landmarks generates up to two intersections (circles can intersect twice), so the total number of resulting intersection points is the combinatorial *2 times (n choose 2)*. The calculation time therefore grows rapidly with *n*. In this case, the variable `casetype` is a vector of `0`s the same size as the variable `range`.

`[latfix,lonfix] = navfix(lat,long,az_range,casetype)` combines ranges and bearings. For each element of `casetype` equal to 1, the corresponding element of `az_range` represents an azimuth to the associated landmark. Where `casetype` is a 0, `az_range` is a range.

`[latfix,lonfix] = navfix(lat,long,az_range,casetype,drlat,drlon)` returns for each possible pairing of landmarks only the intersection that lies closest to the dead reckoning position indicated by `drlat` and `drlon`. When this syntax is used, all included landmarks' bearing lines or range arcs must intersect. If any possible pairing fails, the warning `No Fix` is displayed.

Background

This is a navigational function. It assumes that all latitudes and longitudes are in degrees and all distances are in nautical miles. In navigation, piloting is the practice of fixing one's position based on the observed bearing and ranges *to* fixed landmarks (points of land, lighthouses, smokestacks, etc.) *from* the navigator's vessel. In conformance with navigational practice, bearings are treated as rhumb lines and ranges are treated as the radii of circles on a Mercator projection.

In practice, at least three azimuths (bearings) and/or ranges are required for a usable fix. The resulting intersections are unlikely to coincide exactly. Refer to "Navigation" in the *Mapping Toolbox User's Guide* for a more complete description of the use of this function.

Tips

The outputs of this function are matrices providing the locations of the intersections for all possible pairings of the n entered lines of bearing and range arcs. These matrices therefore have *n-choose-2* rows. In order to allow for two intersections per combination, these matrices have two columns. Whenever there are fewer than two intersections for that combination, one or two NaNs are returned in that row.

When a dead reckoning position is included, these matrices are column vectors.

Examples

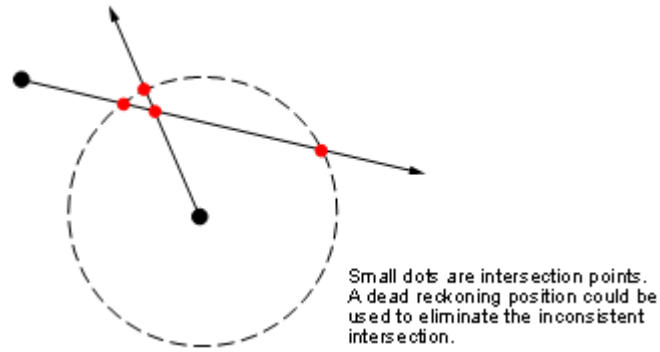
For a fully illustrated example of the application of this function, refer to the "Navigation" section in the *Mapping Toolbox User's Guide*.

Imagine you have two landmarks, at (15ºN,30.4ºW) and (14.8ºN,30.1ºW). You have a visual bearing to the first of 280º and to the second of 160º. Additionally, you have a range to the second of 12 nm. Find the intersection points:

```
[latfix,lonfix] = navfix([15 14.8 14.8],[-30.4 -30.1 -30.1],...
                         [280 160 12],[1 1 0])

latfix =
   14.9591       NaN
   14.9680   14.9208
```

```
   14.9879       NaN
lonfix =
  -30.1599       NaN
  -30.2121  -29.9352
  -30.1708       NaN
```

Here is an illustration of the geometry:



Limitations

Traditional plotting and the `navfix` function are limited to relatively short distances. Visual bearings are in fact great circle azimuths, not rhumb lines, and range arcs are actually arcs of small circles, not of the planar circles plotted on the chart. However, the mechanical ease of the process and the practical limits of visual bearing ranges and navigational radar ranges (~30 nm) make this limitation moot in practice. The error contributed because of these assumptions is minuscule at that scale.

See Also

`crossfix` | `gcxgc` | `gcxsc` | `scxsc` | `rhxrh` | `polyxpoly` | `dreckon` | `gcwaypts` | `legs` | `track`

ned2aer

Purpose

Local Cartesian NED to local spherical AER

Syntax

```
[az,elev,slantRange] = ned2aer(xNorth,yEast,zDown)
[ ___ ] = ned2aer( ___ ,angleUnit)
```

Description

`[az,elev,slantRange] = ned2aer(xNorth,yEast,zDown)` returns coordinates in a local spherical system corresponding to coordinates `xNorth`, `yEast`, `zDown` in a local north-east-down (NED) Cartesian system having the same local origin. Any of the three numerical input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = ned2aer( ___ ,angleUnit)` adds `angleUnit` which specifies the units outputs `az`, `elev`.

Input Arguments

xNorth - Local NED x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the the local NED system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

yEast - Local NED y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the local NED system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

zDown - Local NED z-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the local NED system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as ‘degrees’ (default), or ’radians’.

Data Types
char

Output Arguments

az - Azimuth angles

scalar value | vector | matrix | N-D array

Azimuth angles in the local spherical system, returned as a scalar value, vector, matrix, or N-D array. Azimuths are measured clockwise from north. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the half-open interval [0 360).

elev - Elevation angles

scalar value | vector | matrix | N-D array

Elevation angles in the local spherical system, returned as a scalar value, vector, matrix, or N-D array. Elevations are with respect to a plane perpendicular to the spheroid surface normal. Units determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the closed interval [-90 90].

slantRange - Distances from local origin

scalar value | vector | matrix | N-D array

Distances from origin in the local spherical system, returned as a scalar, vector, matrix, or N-D array. The straight-line, 3-D Cartesian distance is computed.

See Also

`aer2ned` | `enu2aer`

ned2ecef

Purpose

Local Cartesian NED to geocentric ECEF

Syntax

```
[X,Y,Z] =
ned2ecef(xNorth,yEast,zDown,lat0,lon0,h0,spheroid)
[ ___ ] = ned2ecef( ___ ,angleUnits)
```

Description

`[X,Y,Z] = ned2ecef(xNorth,yEast,zDown,lat0,lon0,h0,spheroid)` returns Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian coordinates corresponding to coordinates xNorth, yEast, zDown in a local north-east-down (NED) Cartesian system. Any of the first six numeric input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = ned2ecef( ___ ,angleUnits)` adds `angleUnit` which specifies the units of inputs `lat0` and `lon0`.

Input Arguments

xNorth - Local NED x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the local NED system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

yEast - Local NED y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the local NED system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

zDown - Local NED z-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the local NED system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h0 - Ellipsoidal height of local origin

scalar value | vector | matrix | N-D array

Ellipsoidal height of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one

origin (reference) point, and the value of `h0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

spheroid - Reference spheroid
scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

angleUnit - Units of angles
`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

X - ECEF x-coordinates
scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

Y - ECEF y-coordinates
scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

Z - ECEF y-coordinates
scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

See Also

`aer2ecef` | `ned2geodetic` | `ecef2ned` | `enu2ecef`

ned2ecefv

Purpose

Rotate vector from local NED to geocentric ECEF

Syntax

```
[U,V,W] = ned2ecefv(uNorth,vEast,wDown,lat0,lon0)
[ ___ ] = ned2ecefv( ___ ,angleUnit)
```

Description

`[U,V,W] = ned2ecefv(uNorth,vEast,wDown,lat0,lon0)` returns Cartesian 3-vector components in an Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian system corresponding to the 3-vector with components `uNorth`, `vEast`, `wDown` in a local north-east-down (NED) system. Any of the five numerical input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = ned2ecefv( ___ ,angleUnit)` adds `angleUnit` which specifies the units of inputs `lat0` and `lon0`.

Input Arguments

uNorth - Vector x-components in NED system

scalar value | vector | matrix | N-D array

x-components of one or more Cartesian vectors in the local NED system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

vEast - Vector y-components in NED system

scalar value | vector | matrix | N-D array

y-components of one or more Cartesian vectors in the local ENU system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

wDown - Vector z-components in NED system

scalar value | vector | matrix | N-D array

z-components of one or more Cartesian vectors in the local NED system, specified as a scalar value, vector, matrix, or N-D array.

Data Types
single | double

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

U - Vector x-components in ECEF system

scalar value | vector | matrix | N-D array

x-components of one or more Cartesian vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array.

V - Vector y-components in ECEF system

scalar value | vector | matrix | N-D array

y-components of one or more Cartesian vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array.

W - Vector z-components in ECEF system

scalar value | vector | matrix | N-D array

z-components of one or more Cartesian vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array.

See Also

`ecef2ned` | `ned2ecef` | `enu2ecefv`

Purpose

Local Cartesian NED to geodetic

Syntax

```
[lat,lon,h] = ned2geodetic(xNorth,yEast,zDown,lat0,lon0,h0,
   spheroid)
[ ___ ] = ned2geodetic( ___ ,angleUnits)
```

Description

`[lat,lon,h] = ned2geodetic(xNorth,yEast,zDown,lat0,lon0,h0,spheroid))` returns geodetic coordinates corresponding to coordinates `xNorth`, `yEast`, `zDown` in a local north-east-down (NED) Cartesian system. Any of the first six numeric input arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[ ___ ] = ned2geodetic( ___ ,angleUnits)` adds `angleUnit` which specifies the units of inputs `lat0`, `lon0`, and outputs `lat`, `lon`.

Input Arguments

xNorth - Local NED x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the local NED system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

yEast - Local NED y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the local NED system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

zDown - Local NED z-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the local NED system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` input.

Data Types
single | double

lat0 - Geodetic latitude of local origin

scalar value | vector | matrix | N-D array

Geodetic latitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lat0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

lon0 - Longitude of local origin

scalar value | vector | matrix | N-D array

Longitude of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one origin (reference) point, and the value of `lon0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h0 - Ellipsoidal height of local origin

scalar value | vector | matrix | N-D array

Ellipsoidal height of local origin (reference) point(s), specified as a scalar value, vector, matrix, or N-D array. In many cases there is one

origin (reference) point, and the value of `h0` is scalar, but it need not be. (It may refer to a moving platform, for example). Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

lat - Geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the closed interval [-90 90].

lon - Longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the interval [-180 180].

h - Ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object

See Also

`aer2geodetic` | `enu2geodetic` | `geodetic2ned` | `ned2ecef`

Purpose

Orient regular data grid to oblique aspect

Syntax

```
[Z,lat,lon] = neworig(Z0,R,origin)
[Z,lat,lon] = neworig(Z0,R,origin,'forward')
[Z,lat,lon] = neworig(Z0,R,origin,'inverse')
```

Description

`[Z,lat,lon] = neworig(Z0,R,origin)` and `[Z,lat,lon] = neworig(Z0,R,origin,'forward')` will transform regular data grid `Z0` into an oblique aspect, while preserving the matrix storage format. In other words, the oblique map origin is not necessarily at (0,0) in the Greenwich coordinate frame. This allows operations to be performed on the matrix representing the oblique map. For example, azimuthal calculations for a point in a data grid become row and column operations if the data grid is transformed so that the north pole of the oblique map represents the desired point on the globe.

`R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix. If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to or from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Nearest-neighbor interpolation is used by default. NaN is returned for points outside the grid limits or for which `lat` or `lon` contain NaN. All angles are in units of degrees.

`[Z,lat,lon] = neworig(Z0,R,origin,'inverse')` transforms the regular data grid from the oblique frame to the Greenwich coordinate frame.

The `neworig` function transforms a regular data grid into a new matrix in an altered coordinate system. An analytical use of the new matrix can be realized in conjunction with the `newpole` function. If a selected point is made the *north pole* of the new system, then when a new matrix is created with `neworig`, each row of the new matrix is a constant distance from the selected point, and each column is a constant azimuth from that point.

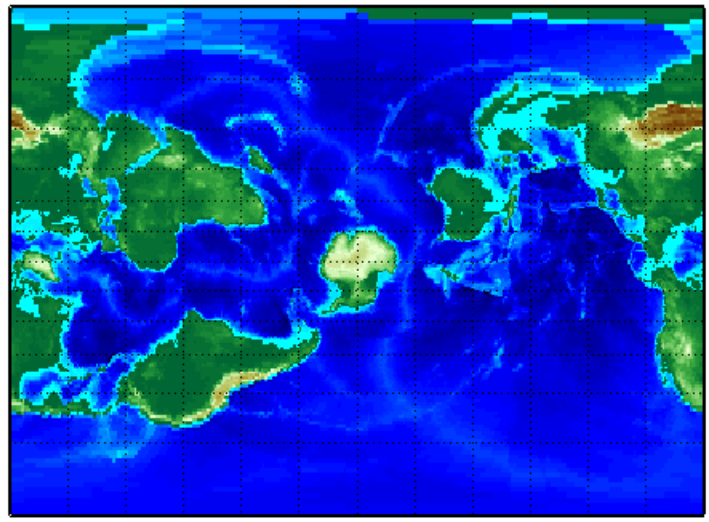
Limitations

`neworig` only supports data grids that cover the entire globe.

Examples

This is the `topo` map transformed to put Sri Lanka at the North Pole:

```
load topo
origin = newpole(7,80)
origin =
   83.0000 -100.0000         0
[Z,lat,lon] = neworig(topo,topolegend,origin);
axesm miller
latlim = [ -90  90];
lonlim = [-180 180];
gratsize = [90 180];
[lat,lon] = meshgrat(latlim,lonlim,gratsize);
surfm(lat,lon,Z)
demcmap(topo)
tightmap
```



See Also

org2pol | rotatem | setpostn

newpole

Purpose

Origin vector to place specific point at pole

Syntax

```
origin = newpole(polelat,polelon)
origin = newpole(polelat,polelon,units)
```

Description

`origin = newpole(polelat,polelon)` provides the `origin` vector for a transformed coordinate system based upon moving the point (`polelat`, `polelon`) to become the north pole singularity in the new system. The origin is a three-element vector of the form `[latitude longitude orientation]`, where the latitude and longitude are the coordinates the new center (`origin`) had in the untransformed system, and the orientation is the azimuth of the true North Pole from the new origin point. For the `newpole` calculation, this orientation is constrained to be always 0º.

`origin = newpole(polelat,polelon,units)` specifies the units of the inputs and output, where *`units`* is any valid angle units string. The default is `'degrees'`.

When developing transverse or oblique projections, you need transformed coordinate systems. One way to define these systems is to establish the point in the original (untransformed) system that will become the new (transformed) *north pole*.

Examples

Take a point and make it the new North Pole:

```
origin = newpole(60,180)

origin =
   30.0000         0         0
```

This makes sense: as a point 30º beyond the true North Pole on the original origin's meridian is pulled up to become the *pole*, the point originally 30º above the origin is pulled down into the origin spot.

See Also

`neworig` | `org2pol` | `putpole`

Purpose

Convert distance from nautical miles to degrees

Syntax

```
deg = nm2deg(nm)
deg = nm2deg(nm,radius)
deg = nm2deg(nm,sphere)
```

Description

`deg = nm2deg(nm)` converts distances from nautical miles to degrees, as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`deg = nm2deg(nm,radius)` converts distances from nautical miles to degrees, as measured along a great circle on a sphere having the specified radius. `radius` must be in units of nautical miles.

`deg = nm2deg(nm,sphere)` converts distances from nautical miles to degrees, as measured along a great circle on a sphere approximating an object in the Solar System. *`sphere`* may be one of the following strings: `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'earth'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, or `'pluto'`, and is case-insensitive.

See Also

`degtorad` | `radtodeg` | `deg2km` | `deg2nm` | `deg2sm` | `km2deg` | `km2nm` | `km2rad` | `km2sm` | `nm2km` | `nm2sm` | `sm2deg` | `sm2km` | `sm2nm`

nm2km

Purpose

Convert nautical miles to kilometers

Syntax

```
km = nm2km(nm)
```

Description

`km = nm2km(nm)` converts distances from nautical miles to kilometers.

Examples

How fast is 30 knots (nautical miles per hour) in kph?

```
km = nm2km(30)
```

```
km =
   55.5600
```

See Also

`deg2km` | `km2deg` | `km2rad` | `rad2km` | `deg2nm` | `nm2deg` | `nm2rad` | `rad2nm` | `deg2sm` | `sm2deg` | `deg2sm` | `sm2rad` | `rad2sm`

Purpose

Convert distance from nautical miles to radians

Syntax

```
rad = nm2rad(nm)
rad = nm2rad(nm,radius)
rad = nm2rad(nm,sphere)
```

Description

`rad = nm2rad(nm)` converts distances from nautical miles to radians as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`rad = nm2rad(nm,radius)` converts distances from nautical miles to radians as measured along a great circle on a sphere having the specified radius. `radius` must be in units of nautical miles.

`rad = nm2rad(nm,sphere)` converts distances from nautical miles to radians, as measured along a great circle on a sphere approximating an object in the Solar System. *`sphere`* may be one of the following strings: `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'earth'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, or `'pluto'`, and is case-insensitive.

See Also

`degtorad` | `radtodeg` | `rad2km` | `km2deg` | `km2nm` | `km2sm` | `rad2nm` | `nm2deg` | `nm2km` | `nm2sm` | `rad2sm` | `sm2deg` | `sm2km` | `sm2nm`

nm2sm

Purpose

Convert nautical to statute miles

Syntax

```
sm = nm2sm(nm)
```

Description

`sm = nm2sm(nm)` converts distances from nautical miles to statute miles.

See Also

`deg2km` | `km2deg` | `km2rad` | `rad2km` | `deg2nm` | `nm2deg` | `nm2rad` | `rad2nm` | `deg2sm` | `sm2deg` | `deg2sm` | `sm2rad` | `rad2sm`

Purpose

Add graphic element pointing to geographic North Pole

Syntax

```
northarrow
northarrow('property',value,...)
```

Description

`northarrow` creates a default north arrow.

`northarrow('property',value,...)` creates a north arrow using the specified property/value pairs. Valid entries for properties are `'latitude'`, `'longitude'`, `'facecolor'`, `'edgecolor'`, `'linewidth'`, and `'scaleratio'`. The `'latitude'` and `'longitude'` properties specify the location of the north arrow. The `'facecolor'`, `'edgecolor'`, and `'linewidth'` properties control the appearance of the north arrow. The `'scaleratio'` property represents the size of the north arrow as a fraction of the size of the axes. A `'scaleratio'` value of 0.10 creates a north arrow one-tenth (1/10) the size of the axes. You can change the appearance (`'facecolor'`, `'edgecolor'`, and `'linewidth'`) of the north arrow using the `set` command.

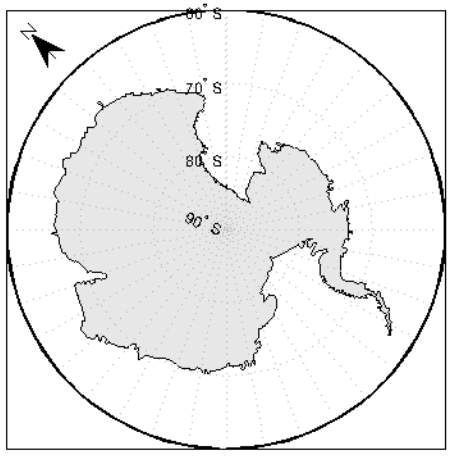
`northarrow` creates a north arrow symbol at the map origin on the displayed map. You can reposition the north arrow symbol by clicking and dragging its icon. Alternate clicking the icon creates an input dialog box that you can also use to change the location of the north arrow.

Modifying some of the properties of the north arrow results in replacement of the original object. Use `HANDLEM('NorthArrow')` to get the handles associated with the north arrow.

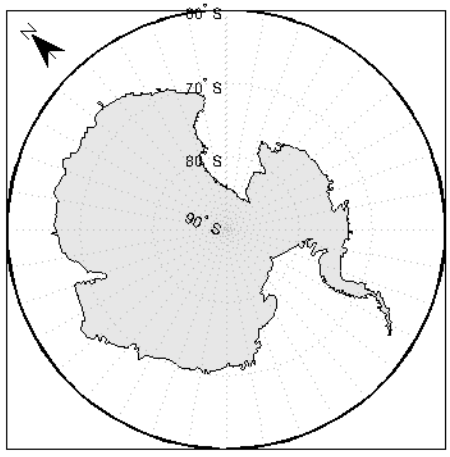
Examples

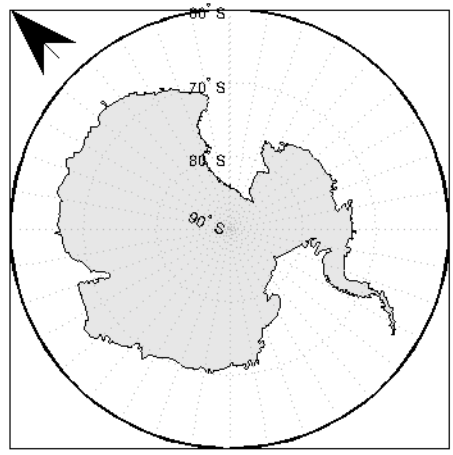
Create a map of the South Pole and then add the north arrow in the upper left of the map.

```
Antarctica = shaperead('landareas', 'UseGeoCoords', true, ...
    'Selector',{@(name) strcmpi(name,{'Antarctica'}), 'Name'});
figure;
worldmap('south pole')
geoshow(Antarctica,'FaceColor',[.9 .9 .9])
northarrow('latitude', -57, 'longitude', 135);
```



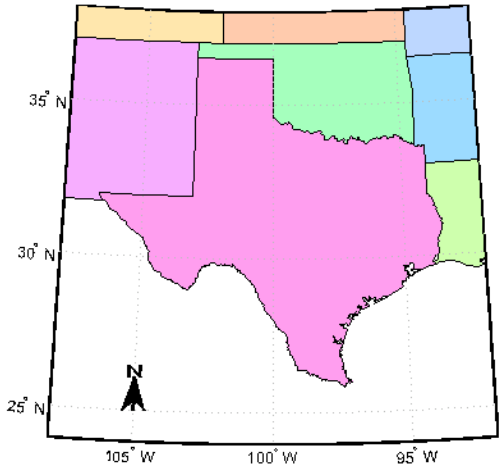
Right-click the north arrow icon to activate the input dialog box. Increase the size of the north arrow symbol by changing the `'ScaleRatio'` property.





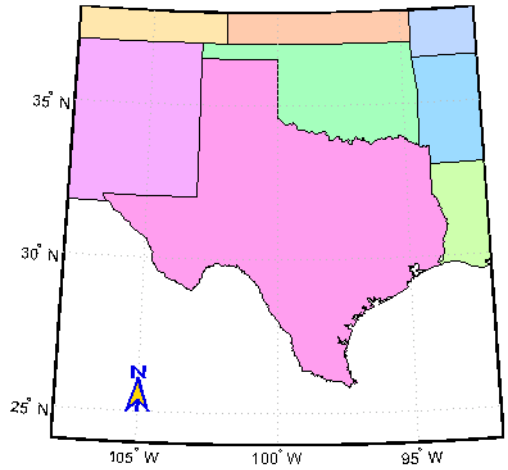
Create a map of Texas and add the north arrow in the lower left of the map.

```
figure; usamap('texas')
states = shaperead('usastatelo.shp','UseGeoCoords',true);
faceColors = makesymbolspec('Polygon',...
         {'INDEX', [1 numel(states)], 'FaceColor', ...
         polcmap(numel(states))});
geoshow(states, 'DisplayType', 'polygon', ...
        'SymbolSpec', faceColors)
northarrow('latitude',25,'longitude',-105,'linewidth',1.5);
```



Change the `'FaceColor'` and `'EdgeColor'` properties of the north arrow.

```
h = handlem('NorthArrow');
set(h,'FaceColor',[1.000 0.8431 0.0000],...
      'EdgeColor',[0.0100 0.0100 0.9000])
```



Limitations

You can draw multiple north arrows on the map. However, the callbacks will only work with the most recently created north arrow. In addition, since it can be displayed outside the map frame limits, the north arrow is not converted into a "mapped" object. Hence, the location and orientation of the north arrow have to be updated manually if the map origin or projection changes.

See Also

`scaleruler`

npi2pi

Purpose

Wrap longitudes to [-180 180] degree interval

Note The `npi2pi` function has been replaced by `wrapTo180` and `wrapToPi`.

Syntax

```
anglout = npi2pi(anglin)
anglout = npi2pi(anglin,units)
anglout = npi2pi(anglin,units,method)
```

Description

`anglout = npi2pi(anglin)` wraps the input angle `anglin` (typically representing a longitude) to lie on the range -180 to 180 (e.g., 270º is renamed -90º).

`anglout = npi2pi(anglin,units)` specifies the angle units with any valid angle units string *`units`*. The default is `'degrees'`.

`anglout = npi2pi(anglin,units,method)` allows special alternative computations to be used when `npi2pi` is called from within certain Mapping Toolbox functions. *`method`* can be one of the following strings:

- `'exact'`, for exact wrapping (the default value)
- `'inward'`, where angles are scaled by a factor of `(1 - epsm('radians'))` before wrapping
- `'outward'`, where angles are scaled by a factor of `(1 + epsm('radians'))` before wrapping

Examples

```
npi2pi(315)

ans =
   -45

npi2pi(181)

ans =
  -179
```

See Also

wrapToPi | wrapTo180

onem

Purpose

Construct regular data grid of 1s

Syntax

```
[Z,refvec] = onem(latlim,lonlim,scale)
```

Description

`[Z,refvec] = onem(latlim,lonlim,scale)` returns a regular data grid consisting entirely of `1`s and a three-element referencing vector for the returned data grid, `Z`.. The two-element vectors `latlim` and `lonlim` define the latitude and longitude limits of the geographic region. They should be of the form `[south north]` and `[west east]`, respectively. The scalar `scale` specifies the number of rows and columns per degree of latitude and longitude.

Examples

```
[Z,refvec] = onem([46,51],[-79,-75],1)

Z =
     1     1     1     1
     1     1     1     1
     1     1     1     1
     1     1     1     1
     1     1     1     1
refvec =
     1    51   -79
```

See Also

`limitm` | `nanm` | `sizem` | `spzerom` | `zerom`

Purpose

Location of north pole in rotated map

Syntax

```
pole = org2pol(origin)
pole = org2pol(origin,units)
```

Description

`pole = org2pol(origin)` returns the location of the North Pole in terms of the coordinate system after transformation based on the input `origin`. The `origin` is a three-element vector of the form `[latitude longitude orientation]`, where `latitude` and `longitude` are the coordinates that the new center (origin) had in the untransformed system, and `orientation` is the azimuth of the true North Pole from the new origin point in the transformed system. The output `pole` is a three-element vector of the form `[latitude longitude meridian]`, which gives the latitude and longitude point in terms of the original untransformed system of the new location of the true North Pole. The meridian is the longitude from the original system upon which the new system is centered.

`pole = org2pol(origin,units)` allows the specification of the angular units of the `origin` vector, where *`units`* is any valid angle units string. The default is `'degrees'`.

When developing transverse or oblique projections, transformed coordinate systems are required. One way to define these systems is to establish the point at which, in terms of the original (untransformed) system, the (transformed) true North Pole will lie.

Examples

Perhaps you want to make (30ºN,0º) the new origin. Where does the North Pole end up in terms of the original coordinate system?

```
pole = org2pol([30 0 0])

pole =
   60.0000         0         0
```

This makes sense: pull a point 30º down to the origin, and the North Pole is pulled down 30º. A little less obvious example is the following:

```
pole = org2pol([5 40 30])

pole =
   59.6245   80.0750   40.0000
```

See Also

neworig | putpole

Purpose

Polygon outlining geographic quadrangle

Syntax

```
[lat,lon] = outlinegeoquad(latlim,lonlim,dlat,dlon)
```

Description

`[lat,lon] = outlinegeoquad(latlim,lonlim,dlat,dlon)` constructs a polygon that traces the outline of the geographic quadrangle defined by `latlim` and `lonlim`. Such a polygon can be useful for displaying the quadrangle graphically, especially on a projection where the meridians and/or parallels do not project to straight lines. `latlim` is a two-element vector of the form: `[southern-limit northern-limit]` and `lonlim` is a two-element vector of the form: `[western-limit eastern-limit]`. `dlat` is a positive scalar that specifies a minimum vertex spacing in degrees to be applied along the meridians that bound the eastern and western edges of the quadrangle. Likewise, `dlon` is a positive scalar that specifies a minimum vertex spacing in degrees of longitude to be applied along the parallels that bound the northern and southern edges of the quadrangle. The outputs `lat` and `lon` contain the vertices of a simple closed polygon with clockwise vertex ordering.

Tips

All input and output angles are in units of degrees. Choose a reasonably small value for `dlat` (a few degrees, perhaps) when using a projection with curved meridians or curved parallels.

To avoid interpolating extra vertices along meridians or parallels, set `dlat` or `dlon` to a value of `Inf`.

Special Cases

The insertion of additional vertices is suppressed at the poles (that is, if `latlim(1) == -90` or `latlim(2) == 90`). If `lonlim` corresponds to a quadrangle width of exactly 360 degrees (`lonlim == [-180 180]`, for example), then it covers a full latitudinal zone and includes two separate, NaN-separated parts, unless either

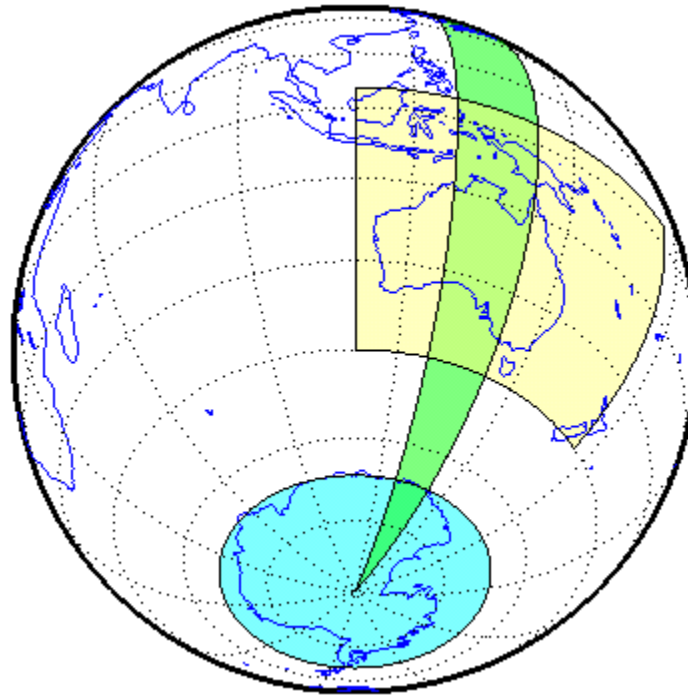
- `latlim(1) == -90` *or* `latlim(2) == 90`, so that only one part is needed—a polygon that follows a parallel clockwise around one of the poles.

- `latlim(1) == -90` *and* `latlim(2) == 90`, so that the quadrangle encompasses the entire planet. In this case, the quadrangle cannot be represented by a latitude-longitude polygon, and an error results.

Examples

Display the outlines of three geographic quadrangles having very different qualities on top of a simple base map:

```
figure('Color','white')
axesm('ortho','Origin',[-45 110],'frame','on','grid','on')
axis off
coast = load('coast');
geoshow(coast.lat, coast.long)

% Quadrangle covering Australia and vicinity
[lat, lon] = outlinegeoquad([-45 5],[110 175],5,5);
geoshow(lat,lon,'DisplayType','polygon','FaceAlpha',0.5);

% Quadrangle covering Antarctic region
antarcticCircleLat = dms2degrees([-66 33 39]);
[lat, lon] = outlinegeoquad([-90 antarcticCircleLat], ...
   [-180 180],5,5);
geoshow(lat,lon,'DisplayType','polygon', ...
       'FaceColor','cyan','FaceAlpha',0.5);

% Quadrangle covering nominal time zone 9 hours ahead of UTC
[lat, lon] = outlinegeoquad([-90 90], 135 + [-7.5 7.5], 5, 5);
geoshow(lat,lon,'DisplayType','polygon', ...
       'FaceColor','green','FaceAlpha',0.5);
```



See Also

`ingeoquad` | `intersectgeoquad`

paperscale

Purpose

Set figure properties for printing at specified map scale

Syntax

```
paperscale(paperdist,punits,surfdist,sunits)
paperscale(paperdist,punits,surfdist,sunits,lat,long)
paperscale(paperdist,punits,surfdist,sunits,lat,long,az)
paperscale(paperdist,punits,surfdist,sunits,lat,long,az,
   gunits)
paperscale(paperdist,punits,surfdist,sunits,lat,long,az,gunits,
radius)
paperscale(scale,...)
[paperXdim,paperYdim] = paperscale(...)
```

Description

`paperscale(paperdist,punits,surfdist,sunits)` sets the figure paper position to print the map in the current axes at the desired scale. The scale is described by the geographic distance that corresponds to a paper distance. For example, a scale of 1 inch = 10 kilometers is specified as `degrees(1,'inch',10,'km')`. See below for an alternate method of specifying the map scale. The surface distance units string *`sunits`* can be any string recognized by `unitsratio`. The paper units string *`punits`* can be any dimensional units string recognized for the figure `PaperUnits` property.

`paperscale(paperdist,punits,surfdist,sunits,lat,long)` sets the paper position so that the scale is correct at the specified geographic location. If omitted, the default is the center of the map limits.

`paperscale(paperdist,punits,surfdist,sunits,lat,long,az)` also specifies the direction along which the scale is correct. If omitted, 90 degrees (east) is assumed.

`paperscale(paperdist,punits,surfdist,sunits,lat,long,az,gunits)` also specifies the units in which the geographic position and direction are given. If omitted, '`degrees`' is assumed.

`paperscale(paperdist,punits,surfdist,sunits,lat,long,az,gunits,radius)` uses the last input to determine the radius of the sphere. `radius` can be one of the strings supported by `km2deg`, or it can be the (numerical) radius of the desired sphere in `zunits`. If omitted, the default radius of the Earth is used..

`paperscale(scale,...)`, where the numeric scale replaces the two property/value pairs, specifies the scale as a ratio between distance on the sphere and on paper. This is commonly notated on maps as 1:scale (e.g. 1:100 000, or 1:1 000 000). For example, `paperscale(100000)` or `paperscale(100000,lat,long)`.

`[paperXdim,paperYdim] = paperscale(...)` returns the computed paper dimensions. The dimensions are in the paper units specified. For the scale calling form, the returned dimensions are in centimeters.

Background

Maps are usually printed at a size that allows an easy comparison of distances measured on paper to distances on the Earth. The relationship of geographic distance and paper distance is termed *scale*. It is usually expressed as a ratio, such as 1 to 100,000 or 1:100,000 or 1 cm = 1 km.

Examples

The small circle measures 10 cm across when printed.

```
axesm mercator
[lat,lon] = scircle1(0,0,km2deg(5));
plotm(lat,lon)
[x,y] = paperscale(1,'centimeter',1,'km'); [x y]

ans =
       13.154       12.509

set(gca,'pos', [ 0 0 1 1])
[x,y] = paperscale(1,'centimeter',1,'km'); [x y]

ans =
       10.195       10.195
```

Limitations

The relationship between the paper and geographic coordinates holds only as long as there are no changes to the display that affect the axes limits or the relationship between geographic coordinates and projected coordinates. Changes of this type include the ellipsoid or scale factor properties of the map axes, or adding elements to the display that cause

MATLAB to modify the axes autoscaling. To be sure that the scale is correct, execute `paperscale` just before printing.

See Also

`pagesetupdlg` | `axesscale` | `daspectm`

Purpose

Project patches on map axes as individual objects

Syntax

```
patchesm(lat,lon,cdata)
patchesm(lat,lon,z,cdata)
patchesm(...,'PropertyName',PropertyValue,...)
h = patchesm(...)
```

Description

`patchesm(lat,lon,cdata)` projects 2-D patch objects onto the current map axes. The input latitude and longitude data must be in the same units as specified in the current map axes. The input cdata defines the patch face color. If the input vectors are `NaN` clipped, then multiple patches are drawn each with a single face. Unlike `fillm` and `fill3m`, `patchesm` will always add the patches to the current map regardless of the current hold state.

`patchesm(lat,lon,z,cdata)` projects 3-D planar patches at the uniform elevation given by scalar `z`.

`patchesm(...,'PropertyName',PropertyValue,...)` uses the patch properties supplied to display the patch. Except for `xdata`, `ydata`, and `zdata`, all patch properties available through `patch` are supported by `patchesm`.

`h = patchesm(...)` returns the handles to the patch objects drawn.

Tips

Differences between patchesm and patchm

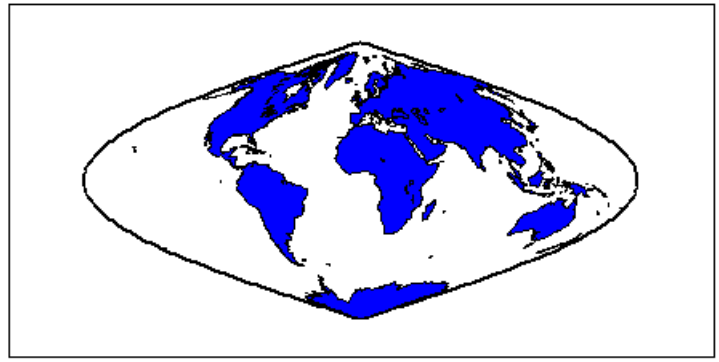
The `patchesm` function is very similar to the `patchm` function. The significant difference is that in `patchesm`, separate patches (delineated by `NaN`s in the inputs `lat` and `lon`) are separated and plotted as distinct patch objects on the current map axes. The advantage to this is that less memory is required. The disadvantage is that multifaced objects cannot be treated as a single object. For example, the archipelago of the Philippines cannot be treated and handled as a single Handle Graphics object.

When Patches Are Completely Trimmed Away

Removing graphic objects that fall outside the map frame is called trimming. If, after trimming no polygons remain to be seen within it, `patchesm` creates no patches and returns an empty 1-by-0 list of handles. When this occurs, automatic reprojection of the patch data (by changing the projection or any of its parameters) is not possible. In cases where some polygons are completely trimmed away but not others, handles returned for the trimmed polygons will be empty. No polygons or rings that have been totally trimmed away can be reprojected; to plot them again, you will need to call `patchesm` again with the original data.

Examples

```
load coast
axesm sinusoid; framem
h = patchesm(lat,long,'b');
```



```
length(h)

ans =
   238
```

See Also

`geoshow` | `fill3m` | `fillm` | `patchm`

Purpose

Project patch objects on map axes

Syntax

```
h = patchm(lat,lon,cdata)
h = patchm(lat,lon,cdata,PropertyName,PropertyValue,...)
h = patchm(lat,lon,PropertyName,PropertyValue,...)
h = patchm(lat,lon,z,cdata)
h = patchm(lat,lon,z,cdata, PropertyName,PropertyValue,...)
```

Description

`h = patchm(lat,lon,cdata)` and `h = patchm(lat,lon,cdata,PropertyName,PropertyValue,...)` project and display patch (polygon) objects defined by their vertices given in `lat` and `lon` on the current map axes. `lat` and `lon` must be vectors. The color data, `cdata`, can be any color data designation supported by the standard MATLAB `patch` function. The object handle or handles, `h`, can be returned.

`h = patchm(lat,lon,PropertyName,PropertyValue,...)` allows any property name/property value pair supported by `patch` to be assigned to the `patchm` object.

`h = patchm(lat,lon,z,cdata)` and `h = patchm(lat,lon,z,cdata, PropertyName,PropertyValue,...)` allow the assignment of an altitude, `z`, to each patch object. The default altitude is `z = 0`.

Tips

How patchm Works

This Mapping Toolbox function is very similar to the standard MATLAB `patch` function. Like its analog, and unlike higher level functions such as `fillm` and `fill3m`, `patchm` adds patch objects to the current map axes regardless of hold state. Except for `XData`, `YData`, and `ZData`, all line properties and styles available through `patch` are supported by `patchm`.

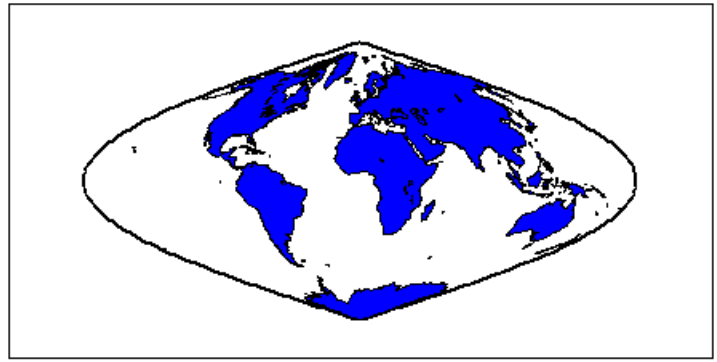
When A Patch Is Completely Trimmed Away

Removing graphic objects that fall outside the map frame is called trimming. If, after trimming to the map frame no polygons remain to be seen within it, `patchm` creates no patches and returns an empty 0-by-1 handle. When this occurs, automatic reprojection of the patch data (by

changing the projection or any of its parameters) will not be possible. Instead, after changing the projection, call `patchm` again.

Examples

```
load coast
axesm sinusoid; framem
h = patchm(lat,long,'b');
```



```
length(h)

ans =
     1
```

See Also

`patchesm` | `fill3m` | `fillm`

Purpose

Project regular data grid on map axes in z = 0 plane

Syntax

```
pcolorm(lat,lon,Z)
pcolorm(latlim,lonlim,Z)
pcolorm(...,prop1,val1,prop2,val2,...)
h = pcolorm(...)
```

Description

`pcolorm(lat,lon,Z)` constructs a surface to represent the data grid `Z` in the current map axes. The surface lies flat in the horizontal plane with its `CData` property set to `Z`. `Lat` and `lon` are vectors or 2-D arrays that define the latitude-longitude graticule mesh on which `Z` is displayed. For a complete description of the various forms that `lat` and `lon` can take, see `surfm`. If the hold state is `'off'`, `pcolorm` clears the current map.

`pcolorm(latlim,lonlim,Z)` defines the graticule using the latitude and longitude limits `latlim` and `lonlim`. These limits should match the geographic extent of `Z`, the data grid. `Latlim` is a two-element vector of the form:

```
[southern_limit northern_limit]
```

Likewise, `lonlim` has the form:

```
[western_limit eastern_limit]
```

A latitude-longitude graticule of size 50-by-100 is constructed. The surface `FaceColor` property is `'texturemap'`, except when `Z` is precisely 50-by-100, in which case it is `'flat'`.

`pcolorm(...,prop1,val1,prop2,val2,...)` applies additional MATLAB graphics properties to the surface via property/value pairs. Any property accepted by the `surface` may be specified, except for `XData`, `YData`, and `ZData`.

`h = pcolorm(...)` returns a handle to the surface object.

Tips

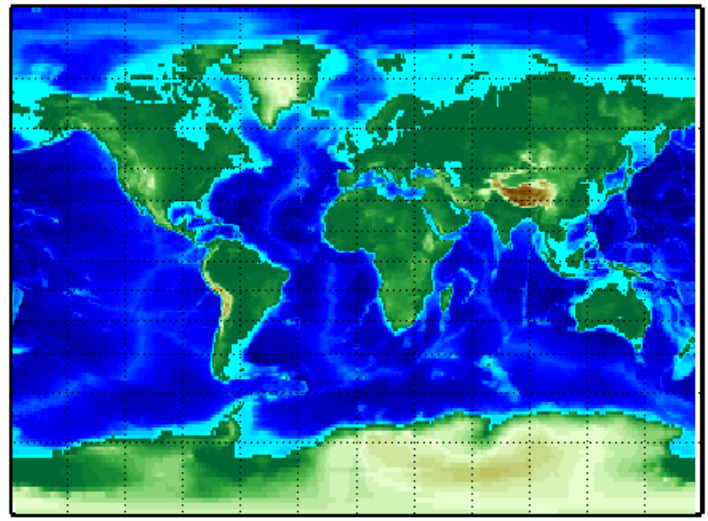
This function warps a data grid to a graticule mesh, which is projected according to the map axes property `MapProjection`. The fineness, or

resolution, of this grid determines the quality of the projection and the speed of plotting it. There is no hard and fast rule for sufficient graticule resolution, but in general, cylindrical projections need fewer graticule points in the longitudinal direction than do complex curve-generating projections.

Examples

Construct a surface to represent the data grid `topo`.

```
figure('Color','white')
load topo
axesm miller
axis off; framem on; gridm on;
[lat lon] = meshgrat(topo,topolegend,[90 180]);
pcolorm(lat,lon,topo)
demcmap(topo)
tightmap
```



See Also

`geoshow` | `meshgrat` | `meshm` | `surfacem` | `surfm`

Purpose

Convert pixel coordinates to latitude-longitude coordinates

Syntax

```
[lat, lon] = pix2latlon(R,row,col)
```

Description

`[lat, lon] = pix2latlon(R,row,col)` calculates latitude-longitude coordinates `lat`, `lon` from pixel coordinates `row`, `col`. `R` is either a 3-by-2 referencing matrix that transforms intrinsic pixel coordinates to geographic coordinates, or a `spatialref.GeoRasterReference` object. `row` and `col` are vectors or arrays of matching size. The outputs `lat` and `lon` have the same size as `row` and `col`.

Examples

Find the latitude and longitude of the upper left outer corner of a 2-by-2 degree gridded data set.

```
R = makerefmat(1, 89, 2, 2);
[UL_lat, UL_lon] = pix2latlon(R, .5, .5)
```

The output appears as follows:

```
UL_lat =
    88
UL_lon =
     0
```

Find the latitude and longitude of the lower right outer corner of a 2-by-2 degree gridded data set.

```
[LR_lat, LR_lon] = pix2latlon(R, 90.5, 180.5)
```

The output appears as follows:

```
LR_lat =
   268
LR_lon =
   360
```

See Also

`latlon2pix` | `makerefmat` | `pix2map`

pix2map

Purpose

Convert pixel coordinates to map coordinates

Syntax

```
[x,y] = pix2map(R,row,col)
s = pix2map(R,row,col)
[...] = pix2map(R,p)
```

Description

`[x,y] = pix2map(R,row,col)` calculates map coordinates `x,y` from pixel coordinates `row,col`. `R` is either a 3-by-2 referencing matrix defining a two-dimensional affine transformation from intrinsic pixel coordinates to map coordinates, or a `spatialref.MapRasterReference` object. `row` and `col` are vectors or arrays of matching size. The outputs `x` and `y` have the same size as `row` and `col`.

`s = pix2map(R,row,col)` combines `x` and `y` into a single array `s`. If `row` and `col` are column vectors of length `n`, then `s` is an `n`-by-2 matrix and each row `(s(k,:))` specifies the map coordinates of a single point. Otherwise, `s` has size `[size(row) 2]`, and `s(k1,k2,...,kn,:)` contains the map coordinates of a single point.

`[...] = pix2map(R,p)` combines `row` and `col` into a single array `p`. If `row` and `col` are column vectors of length `n`, then `p` should be an `n`-by-2 matrix such that each row `(p(k,:))` specifies the pixel coordinates of a single point. Otherwise, `p` should have size `[size(row) 2]`, and `p(k1,k2,...,kn,:)` should contain the pixel coordinates of a single point.

Examples

```
% Find the map coordinates for the pixel at (100,50).
R = worldfileread('concord_ortho_w.tfw');
[x,y] = pix2map(R,100,50);
```

See Also

`makerefmat` | `map2pix` | `pix2latlon` | `worldfileread`

Purpose

Compute pixel centers for georeferenced image or data grid

Syntax

```
[x,y] = pixcenters(R, height, width)
[x,y] = pixcenters(r,sizea)
[x,y] = pixcenters(..., 'makegrid')
```

Description

`[x,y] = pixcenters(R, height, width)` returns the spatial coordinates of a spatially-referenced image or regular gridded data set. `R` is either a 3-by-2 referencing matrix defining a 2-dimensional affine transformation from intrinsic pixel coordinates to map coordinates, or a `spatialref.MapRasterReference` object. `height` and `width` are the image dimensions. If `r` does not include a rotation (i.e., `r(1,1) = r(2,2) = 0`), then `x` is a 1-by-`width` vector and `y` is a `height`-by-1 vector. In this case, the spatial coordinates of the pixel in row `row` and column `col` are given by `x(col), y(row)`. Otherwise, `x` and `y` are each a `height`-by-`width` matrix such that `x(col,row), y(col,row)` are the coordinates of the pixel with subscripts `(row,col)`.

`[x,y] = pixcenters(r,sizea)` accepts the size vector `sizea = [height, width, ...]` instead of `height` and `width`.

`[x,y] = pixcenters(info)` accepts a scalar struct array with the fields

`'RefMatrix'`	3-by-2 referencing matrix
`'Height'`	Scalar number
`'Width'`	Scalar number

`[x,y] = pixcenters(..., 'makegrid')` returns `x` and `y` as `height`-by-`width` matrices even if `r` is irrotational. This syntax can be helpful when you call `pixcenters` from within a function or script.

Tips

For more information on referencing matrices, see the `makerefmat` reference page.

`pixcenters` is useful for working with `surf`, `mesh`, or `surface`, and for coordinate transformations.

Examples

```
[Z,R] = arcgridread('MtWashington-ft.grd');
[x,y] = pixcenters(R, size(Z));
h = surf(x,y,Z); axis equal; demcmap(Z)
set(h,'EdgeColor','none')
xlabel('x (easting in meters)')
ylabel('y (northing in meters')
zlabel('elevation in feet')
```

See Also

arcgridread | makerefmat | mapbbox | mapoutline | pix2map | worldfileread | mapshow

Purpose

Toggle and control display of parallel labels

Syntax

```
plabel
plabel('on')
plabel('off')
plabel(meridian)
plabel(MapAxesPropertyName,PropertyValue,...)
```

Description

`plabel` toggles the visibility of parallel labeling on the current map axes.

`plabel('on')` sets the visibility of parallel labels to `'on'`.

`plabel('off')` sets the visibility of parallel labels to `'off'`.

`plabel('reset')` resets the displayed parallel labels using the currently defined parallel label properties.

`plabel(meridian)` sets the value of the `PLabelMeridian` property of the map axes to the value meridian. This determines the meridian upon which the labels are placed (see `axesm`). The options for `meridian` are a scalar longitude or the strings `'east'`, `'west'`, or `'prime'`.

`plabel(MapAxesPropertyName,PropertyValue,...)` allows paired map axes property names and property values to be passed in. For a complete description of map axes properties, see the `axesm` reference page.

Parallel label handles can be returned in `h` if desired.

See Also

`axesm` | `setm` | `mlabel`

plot3m

Purpose

Project 3-D lines and points on map axes

Syntax

```
h = plot3m(lat,lon,z)
h = plot3m(lat,lon,linetype)
h = plot3m(lat,lon,PropertyName,PropertyValue,...)
```

Description

`h = plot3m(lat,lon,z)` displays projected line objects on the current map axes. `lat` and `lon` are the latitude and longitude coordinates, respectively, of the line object to be projected. Note that this ordering is conceptually reversed from the MATLAB `line` function, because the *vertical* (*y*) coordinate comes first. However, the ordering latitude, then longitude, is standard geographic usage. `lat` and `lon` must be the same size, and in the `AngleUnits` of the map axes. `z` is the altitude data associated with each point in `lat` and `lon`. The object handle for the displayed line can be returned in `h`.

The units of `z` are arbitrary, except when using the Globe projection. In the case of `globe`, `z` should have the same units as the radius of the earth or semimajor axis specified in the `'geoid'` (reference ellipsoid) property of the map axes. This implies that when the reference ellipsoid is a unit sphere, the units of `z` are earth radii.

`h = plot3m(lat,lon,linetype)` allows the specification of the line style, where *`linetype`* is any string recognized by the MATLAB `line` function.

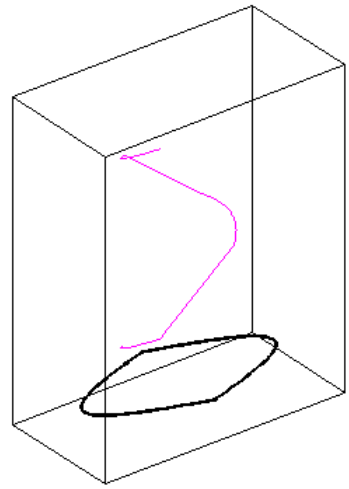
`h = plot3m(lat,lon,PropertyName,PropertyValue,...)` allows the specification of any number of property name/property value pairs for any properties recognized by the MATLAB `line` function except for `XData`, `YData`, and `ZData`.

Tips

`plot3m` is the mapping equivalent of the MATLAB `plot3` function.

Examples

```
axesm sinusoid; framem; view(3)
[lats,longs] = interpm([45 -45 -45 45 45 -45]',...
                       [-100 -100 100 100 -100 -100]',1);
z = (1:671)'/100;
plot3m(lats,longs,z,'m')
```



See Also

linem | plot3 | plotm

plotm

Purpose

Project 2-D lines and points on map axes

Syntax

```
h = plotm(lat,lon)
h = plotm(lat,lon,linetype)
h = plotm(lat,lon,PropertyName,PropertyValue,...)
h = plotm([lat lon],...)
```

Description

`h = plotm(lat,lon)` displays projected line objects on the current map axes. `lat` and `lon` are the latitude and longitude coordinates, respectively, of the line object to be projected. Note that this ordering is conceptually reversed from the MATLAB `line` function, because the *vertical* (*y*) coordinate comes first. However, the ordering latitude, then longitude, is standard geographic usage. `lat` and `lon` must be the same size, and in the `AngleUnits` of the map axes. The object handle for the displayed line can be returned in `h`.

`h = plotm(lat,lon,linetype)` allows the specification of the line style, where *`linetype`* is any string recognized by the MATLAB `line` function.

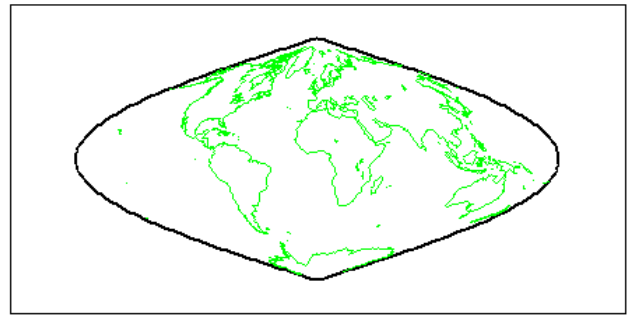
`h = plotm(lat,lon,PropertyName,PropertyValue,...)` allows the specification of any number of property name/property value pairs for any properties recognized by the MATLAB `line` function except for `XData`, `YData`, and `ZData`.

`h = plotm([lat lon],...)` allows the coordinates to be packed into a single two-column matrix.

`plotm` is the mapping equivalent of the MATLAB `plot` function.

Examples

```
load coast
axesm sinusoid; framem
plotm(lat,long,'g')
```



See Also

linem | plot | plot3m

polcmap

Purpose

Colormaps appropriate to political regions

Syntax

```
polcmap
polcmap(ncolors)
polcmap(ncolors,maxsat)
polcmap(ncolors,huelimits,saturationlimits,valuelimits)
cmap = polcmap(...)
```

Description

`polcmap` applies a random muted colormap to the current figure. The size of the colormap is the same as the existing colormap.

`polcmap(ncolors)` creates a colormap with the specified number of colors.

`polcmap(ncolors,maxsat)` controls the maximum saturation of the colors. Larger maximum saturation values produce brighter, more saturated colors. If omitted, the default is 0.5.

`polcmap(ncolors,huelimits,saturationlimits,valuelimits)` controls the colors. Hue, saturation, and value are randomly selected values within the limit vectors. These are two-element vectors of the form `[min max]`. Valid values range from 0 to 1. As the hue varies from 0 to 1, the resulting color varies from red, through yellow, green, cyan, blue, and magenta, back to red. When the saturation is 0, the colors are unsaturated; they are simply shades of gray. When the saturation is 1, the colors are fully saturated; they contain no white component. As the value varies from 0 to 1, the brightness increases.

`cmap = polcmap(...)` returns the colormap without applying it to the figure.

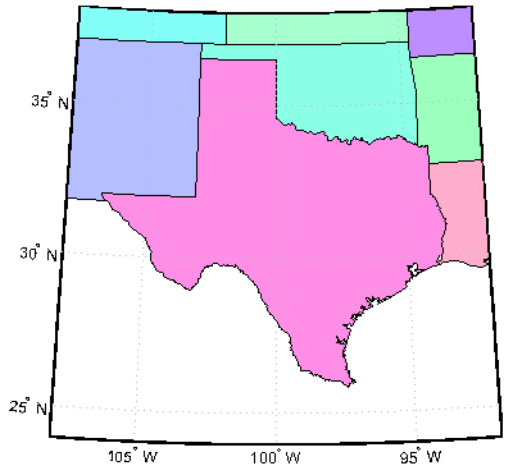
Tips

You cannot use `polcmap` to alter the colors of displayed patches drawn by `geoshow` or `mapshow`. The patches must have been rendered by `displaym`. However, you can color patches using `polcmap` when you call `geoshow` or `mapshow`, as shown below.

Examples

Draw a map of Texas and surrounding states. Color the patches with a symbolspec constructed using `polcmap`:

```
figure; usamap('texas')
states = shaperead('usastatelo.shp','UseGeoCoords',true);
faceColors = makesymbolspec('Polygon',...
     {'INDEX', [1 numel(states)], 'FaceColor', ...
      polcmap(numel(states))});
geoshow(states, 'DisplayType', 'polygon', ...
       'SymbolSpec', faceColors)
```



Note that the colors you obtain for this example can vary from what you see above because `polcmap` computes them randomly.

See Also

`demcmap` | `colormap`

poly2ccw

Purpose

Convert polygon contour to counterclockwise vertex ordering

Syntax

```
[x2, y2] = poly2ccw(x1, y1)
```

Description

`[x2, y2] = poly2ccw(x1, y1)` arranges the vertices in the polygonal contour (`x1, y1`) in counterclockwise order, returning the result in `x2` and `y2`. If `x1` and `y1` can contain multiple contours, represented either as `NaN`-separated vectors or as cell arrays, then each contour is converted to clockwise ordering. `x2` and `y2` have the same format (`NaN`-separated vectors or cell arrays) as `x1` and `y1`.

Examples

Convert a clockwise-ordered square to counterclockwise ordering.

```
x1 = [0 0 1 1 0];
y1 = [0 1 1 0 0];
ispolycw(x1, y1)

ans =
         1

[x2, y2] = poly2ccw(x1, y1);
ispolycw(x2, y2)
ans =
         0
```

See also

`ispolycw`, `poly2cw`, `polybool`

Purpose

Convert polygon contour to clockwise vertex ordering

Syntax

```
[x2, y2] = poly2cw(x1, y1)
```

Description

`[x2, y2] = poly2cw(x1, y1)` arranges the vertices in the polygonal contour (`x1`, `y1`) in clockwise order, returning the result in `x2` and `y2`. If `x1` and `y1` can contain multiple contours, represented either as `NaN`-separated vectors or as cell arrays, then each contour is converted to clockwise ordering. `x2` and `y2` have the same format (`NaN`-separated vectors or cell arrays) as `x1` and `y1`.

Examples

Convert a counterclockwise-ordered square to clockwise ordering.

```
x1 = [0 1 1 0 0];
y1 = [0 0 1 1 0];
ispolycw(x1, y1)

ans =
         0

[x2, y2] = poly2cw(x1, y1);
ispolycw(x2, y2)

ans =
         1
```

See also

`ispolycw`, `poly2ccw`, `polybool`

poly2fv

Purpose

Convert polygonal region to patch faces and vertices

Syntax

```
[F,V] = poly2fv(x,y)
```

Description

`[F,V] = poly2fv(x,y)` converts the polygonal region represented by the contours `(x,y)` into a faces matrix, `F`, and a vertices matrix, `V`, that can be used with the `patch` function to display the region. If the polygon represented by `x` and `y` has multiple parts, either the `NaN`-separated vector format or the cell array format may be used. The `poly2fv` function creates triangular faces.

Most Mapping Toolbox functions adhere to the convention that individual contours with clockwise-ordered vertices are external contours and individual contours with counterclockwise-ordered vertices are internal contours. Although the `poly2fv` function ignores vertex order, you should follow the convention when creating contours to ensure consistency with other functions.

Examples

Display a rectangular region with two holes using a single patch object.

```
% External contour, rectangle.
x1 = [0 0 6 6 0];
y1 = [0 3 3 0 0];

% First hole contour, square.
x2 = [1 2 2 1 1];
y2 = [1 1 2 2 1];

% Second hole contour, triangle.
x3 = [4 5 4 4];
y3 = [1 1 2 1];

% Compute face and vertex matrices.
[f, v] = poly2fv({x1, x2, x3}, {y1, y2, y3});

% Display the patch.
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
```

```
 'EdgeColor', 'none');
axis off, axis equal
```

See the documentation for the function `polybool` for additional examples illustrating `poly2fv`.

See also

`ispolycw`, `patch`, `poly2cw`, `poly2ccw`, `polybool`

polybool

Purpose

Set operations on polygonal regions

Syntax

```
[x,y] = polybool(flag,x1,y1,x2,y2)
```

Description

`[x,y] = polybool(flag,x1,y1,x2,y2)` performs the polygon set operation identified by `flag`. A valid flag string is any one of the following alternatives:

- Region intersection: `'intersection'`, `'and'`, `'&'`
- Region union: `'union'`, `'or'`, `'|'`, `'+'`, `'plus'`
- Region subtraction: `'subtraction'`, `'minus'`, `'-'`
- Region exclusive or: `'exclusiveor'` , `'xor'`

Polygons processed via `polybool` are assumed to be in a Cartesian coordinate system. The polygon inputs are `NaN`-delimited vectors, or cell arrays containing individual polygonal contours. The result is output using the same format as the input. Geographic data that encompasses a pole cannot be used directly. Use `flatearthpoly` to convert polygons that contain a pole to Cartesian coordinates.

Most Mapping Toolbox functions adhere to the convention that individual contours with clockwise-ordered vertices are external contours and individual contours with counterclockwise-ordered vertices are internal contours. Although the `polybool` function ignores vertex order, you should follow the convention when creating contours to ensure consistency with other functions.

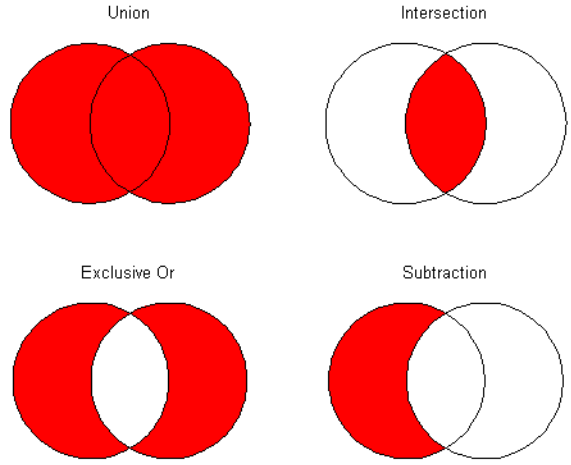
Examples

Example 1

Set operations on two overlapping circular regions:

```
theta = linspace(0, 2*pi, 100);
x1 = cos(theta) - 0.5;
y1 = -sin(theta);    % -sin(theta) to make a clockwise contour
x2 = x1 + 1;
y2 = y1;
[xa, ya] = polybool('union', x1, y1, x2, y2);
```

```
[xb, yb] = polybool('intersection', x1, y1, x2, y2);
[xc, yc] = polybool('xor', x1, y1, x2, y2);
[xd, yd] = polybool('subtraction', x1, y1, x2, y2);

subplot(2, 2, 1)
patch(xa, ya, 1, 'FaceColor', 'r')
axis equal, axis off, hold on
plot(x1, y1, x2, y2, 'Color', 'k')
title('Union')

subplot(2, 2, 2)
patch(xb, yb, 1, 'FaceColor', 'r')
axis equal, axis off, hold on
plot(x1, y1, x2, y2, 'Color', 'k')
title('Intersection')

subplot(2, 2, 3)
% The output of the exclusive-or operation consists of disjoint
% regions.  It can be plotted as a single patch object using the
% face-vertex form.  Use poly2fv to convert a polygonal region
% to face-vertex form.
[f, v] = poly2fv(xc, yc);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
  'EdgeColor', 'none')
axis equal, axis off, hold on
plot(x1, y1, x2, y2, 'Color', 'k')
title('Exclusive Or')

subplot(2, 2, 4)
patch(xd, yd, 1, 'FaceColor', 'r')
axis equal, axis off, hold on
plot(x1, y1, x2, y2, 'Color', 'k')
title('Subtraction')
```

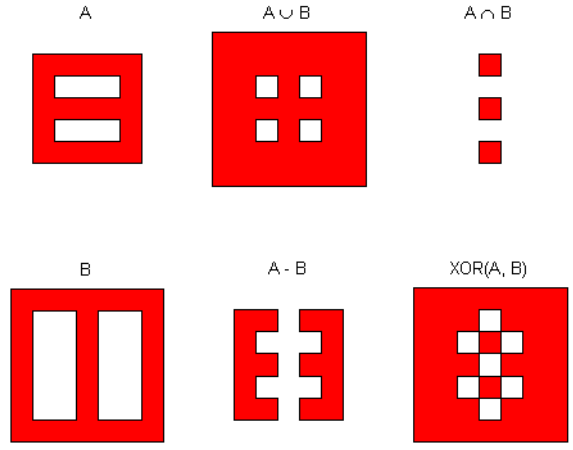


Example 2

Set operations on regions with holes

```
Ax = {[1 1 6 6 1], [2 5 5 2 2], [2 5 5 2 2]};
Ay = {[1 6 6 1 1], [2 2 3 3 2], [4 4 5 5 4]};
subplot(2, 3, 1)
[f, v] = poly2fv(Ax, Ay);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
  'EdgeColor', 'none')
axis equal, axis off, axis([0 7 0 7]), hold on
for k = 1:numel(Ax), plot(Ax{k}, Ay{k}, 'Color', 'k'), end
title('A')

Bx = {[0 0 7 7 0], [1 3 3 1 1], [4 6 6 4 4]};
By = {[0 7 7 0 0], [1 1 6 6 1], [1 1 6 6 1]};
subplot(2, 3, 4);
[f, v] = poly2fv(Bx, By);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
  'EdgeColor', 'none')
axis equal, axis off, axis([0 7 0 7]), hold on
for k = 1:numel(Bx), plot(Bx{k}, By{k}, 'Color', 'k'), end
```

```
title('B')

subplot(2, 3, 2)
[Cx, Cy] = polybool('union', Ax, Ay, Bx, By);
[f, v] = poly2fv(Cx, Cy);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
  'EdgeColor', 'none')
axis equal, axis off, axis([0 7 0 7]), hold on
for k = 1:numel(Cx), plot(Cx{k}, Cy{k}, 'Color', 'k'), end
title('A \cup B')

subplot(2, 3, 3)
[Dx, Dy] = polybool('intersection', Ax, Ay, Bx, By);
[f, v] = poly2fv(Dx, Dy);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
  'EdgeColor', 'none')
axis equal, axis off, axis([0 7 0 7]), hold on
for k = 1:numel(Dx), plot(Dx{k}, Dy{k}, 'Color', 'k'), end
title('A \cap B')

subplot(2, 3, 5)
[Ex, Ey] = polybool('subtraction', Ax, Ay, Bx, By);
[f, v] = poly2fv(Ex, Ey);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
  'EdgeColor', 'none')
axis equal, axis off, axis([0 7 0 7]), hold on
for k = 1:numel(Ex), plot(Ex{k}, Ey{k}, 'Color', 'k'), end
title('A - B')

subplot(2, 3, 6)
[Fx, Fy] = polybool('xor', Ax, Ay, Bx, By);
[f, v] = poly2fv(Fx, Fy);
patch('Faces', f, 'Vertices', v, 'FaceColor', 'r', ...
  'EdgeColor', 'none')
axis equal, axis off, axis([0 7 0 7]), hold on
for k = 1:numel(Fx), plot(Fx{k}, Fy{k}, 'Color', 'k'), end
title('XOR(A, B)')
```



See Also

bufferm | flatearthpoly | ispolycw | poly2cw | poly2ccw | poly2fv | polyjoin | polysplit

Purpose

Polygon branch cuts for holes

Syntax

```
[lat2,long2] = polycut(lat,long)
```

Description

`[lat2,long2] = polycut(lat,long)` connects the contour and holes of polygons using optimal branch cuts. Polygons are input as `NaN`-delimited vectors, or as cell arrays containing individual polygons in each element with the outer face separated from the subsequent inner faces by `NaN`s. Multiple polygons outputs are separated by `NaN`s.

See Also

`polybool` | `polysplit` | `polyjoin`

polyjoin

Purpose

Convert line or polygon parts from cell arrays to vector form

Syntax

```
[lat,lon] = polyjoin(latcells,loncells)
```

Description

`[lat,lon] = polyjoin(latcells,loncells)` converts polygons from cell array format to column vector format. In cell array format, each element of the cell array is a vector that defines a separate polygon.

Tips

A polygon may consist of an outer contour followed by holes separated with `NaN`s. In vector format, each vector may contain multiple faces separated by `NaN`s. There is no structural distinction between outer contours and holes in vector format.

Examples

```
latcells = {[1 2 3]'; 4; [5 6 7 8 NaN 9]'};
loncells = {[9 8 7]'; 6; [5 4 3 2 NaN 1]'};
[lat,lon] = polyjoin(latcells,loncells);
[lat lon]

ans =
     1     9
     2     8
     3     7
   NaN   NaN
     4     6
   NaN   NaN
     5     5
     6     4
     7     3
     8     2
   NaN   NaN
     9     1
```

See Also

`polybool` | `polycut` | `polysplit`

Purpose

Merge line segments with matching endpoints

Syntax

```
[latMerged, lonMerged] = polymerge(lat, lon)
[latMerged, lonMerged] = polymerge(lat, lon, tol)
[latMerged, lonMerged] = polymerge(lat, lon, tol,
   outputFormat)
```

Description

`[latMerged, lonMerged] = polymerge(lat, lon)` accepts a multipart line in latitude-longitude with vertices stored in arrays `lat` and `lon`, and merges the parts wherever a pair of end points coincide. For this purpose, an end point can be either the first or last vertex in a given part. When a pair of parts are merged, they are combined into a single part and the duplicate common vertex is removed. If two first vertices coincide or two last vertices coincide, then the vertex order of one of the parts will be reversed. A merge is applied anywhere that the end points of exactly two distinct parts coincide, so that an indefinite number of parts can be chained together in a single call to `polymerge`. If three or more distinct parts share a common end point, however, the choice of which parts to merge is ambiguous and therefore none of the corresponding parts are connected at that common point.

The inputs `lat` and `lon` can be column or row vectors with NaN-separated parts (and identical NaN locations in each array), or they can be cell arrays with each part in a separate cell. The form of the output arrays, `latMerged` and `lonMerged`, matches the inputs in this regard.

`[latMerged, lonMerged] = polymerge(lat, lon, tol)` combines line segments whose endpoints are separated by less than the circular tolerance, `tol`. `tol` has the same units as the polygon input.

`[latMerged, lonMerged] = polymerge(lat, lon, tol, outputFormat)` allows you to request either the NaN-separated vector form for the output (set `outputFormat` to `'vector'`), or the cell array form (set `outputFormat` to `'cell'`).

Examples

```
lat = [1 2 3 NaN 6 7 8 9 NaN 6 5 4 3 NaN 12 13 14 ...
   NaN 9 10 11 12]';
lon = lat;
[lat2, lon2] = polymerge(lat, lon);
[lat2, lon2]

ans =

     1     1
     2     2
     3     3
     4     4
     5     5
     6     6
     7     7
     8     8
     9     9
    10    10
    11    11
    12    12
    13    13
    14    14
   NaN   NaN
```

See Also

polyjoin | polysplit

Purpose

Convert line or polygon parts from vector form to cell arrays

Syntax

```
[latcells,loncells] = polysplit(lat,lon)
```

Description

`[latcells,loncells] = polysplit(lat,lon)` returns the `NaN`-delimited segments of the vectors `lat` and `lon` as N-by-1 cell arrays with one polygon segment per cell. `lat` and `lon` must be the same size and have identically-placed `NaN`s. The polygon segments are column vectors if `lat` and `lon` are column vectors, and row vectors otherwise.

Examples

```
lat = [1 2 3 NaN 4 NaN 5 6 7 8 9]';
lon = [9 8 7 NaN 6 NaN 5 4 3 2 1]';
[latcells,loncells] = polysplit(lat,lon);
[latcells loncells]

ans =
    [3x1 double]    [3x1 double]
    [         4]    [         6]
    [5x1 double]    [5x1 double]
```

See Also

`isshapemultipart` | `polybool` | `polycut` | `polyjoin`

polyxpoly

Purpose

Intersection points for lines or polygon edges

Syntax

```
[xi,yi] = polyxpoly(x1,y1,x2,y2)
[xi,yi,ii] = polyxpoly(...)
[xi,yi] = polyxpoly(...,'unique')
```

Description

`[xi,yi] = polyxpoly(x1,y1,x2,y2)` returns the intersection points of two polylines in a planar, Cartesian system. `x1` and `y1` are vectors containing the *x*- and *y*-coordinates of the vertices in the first polyline, and `x2` and `y2` contain the vertices in the second polyline. The output variables, `xi` and `yi`, are column vectors containing the *x*- and *y*-coordinates of each point at which a segment of the first polyline intersects a segment of the second. In the case of overlapping, collinear segments, the intersection is actually a line segment rather than a point, and both endpoints are included in `xi`, `yi`.

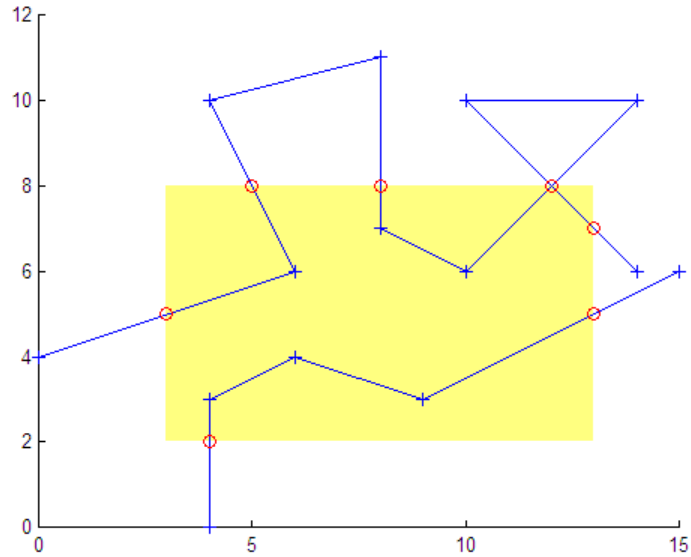
`[xi,yi,ii] = polyxpoly(...)` returns a two-column array of line segment indices corresponding to the intersection points. The *k*-th row of `ii` indicates which polyline segments give rise to the intersection point `xi(k)`, `yi(k)`. To remember how these indices work, just think of segments and vertices as fence sections and posts. The *i*-th fence section connects the *i*-th post to the (*i*+1)-th post. In general, letting *i* and *j* denote the scalar values comprised by the *k*-th row of `ii`, the intersection indicated by that row occurs where the *i*-th segment of the first polyline intersects the *j*-th segment of the second polyline. But when an intersection falls precisely on a vertex of the first polyline, then *i* is the index of that vertex. Likewise with the second polyline and the index *j*. In the case of an intersection at the *i*-th vertex of the first line, for example, `xi(k)` equals `x1(i)` and `yi(k)` equals `y1(i)`. In the case of intersections between vertices, *i* and *j* can be interpreted as follows: the segment connecting `x1(i)`, `y1(i)` to `x1(i+1)`, `y1(i+1)` intersects the segment connecting `x2(j)`, `y2(j)` to `x2(j+1)`, `y2(j+1)` at the point `xi(k)`, `yi(k)`.

`[xi,yi] = polyxpoly(...,'unique')` filters out duplicate intersections, which may result if the input polylines are self-intersecting.

Examples

Use the `polyxpoly` function to find the intersection points between a rectangle and a two-part polyline.

```
% Define and fill a rectangular area in the plane
xlimit = [3 13];
ylimit = [2  8];
xbox = xlimit([1 1 2 2 1]);
ybox = ylimit([1 2 2 1 1]);
mapshow(xbox,ybox,'DisplayType','polygon','LineStyle','none')

% Define and display a two-part polyline
x = [0 6  4  8 8 10 14 10 14 NaN 4 4 6 9 15];
y = [4 6 10 11 7  6 10 10  6 NaN 0 3 4 3  6];
mapshow(x,y,'Marker','+')

% Intersect the polyline with the rectangle
[xi, yi] = polyxpoly(x, y, xbox, ybox);
mapshow(xi,yi,'DisplayType','point','Marker','o')
```

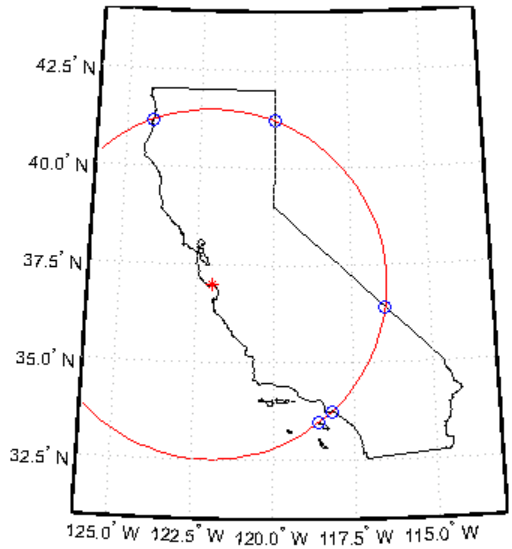



```
% Display the intersection points; note that the point (12, 8)
% appears twice because of a self-intersection near the end of
% the first part of the polyline.
[xi yi]

ans =

     3     5
     5     8
     8     8
    12     8
    12     8
    13     7
     4     2
    13     5
```

```
% You could suppress this duplicate point by using the 'unique'
% option.
[xi, yi] = polyxpoly(x, y, xbox, ybox, 'unique');
[xi yi]

ans =

     3     5
     5     8
     8     8
    12     8
    13     7
     4     2
    13     5
```

Use the `polyxpoly` function to find the intersection points between the state of California and a small circle.

```
california = shaperead('usastatehi',...
   'UseGeoCoords', true,...
   'Selector',{@(name) strcmpi(name,'California'), 'Name'});
usamap('california')
geoshow(california, 'FaceColor', 'none')

lat0 = 37; lon0 = -122; rad = 500;
[latc, lonc] = scircle1(lat0, lon0, km2deg(rad));
plotm(lat0, lon0, 'r*')
plotm(latc, lonc, 'r')

[loni, lati] = polyxpoly(lonc, latc, ...
   california.Lon', california.Lat');
plotm(lati, loni, 'bo')
```



See Also

crossfix | gcxgc | gcxsc | navfix | rhxrh | scxsc

Purpose

View map at printed size

Description

The appearance of a map onscreen can differ from the final printed output. This results from the difference in the size and shape of the figure window and the area the figure occupies on the printed page. A map that appears readable on screen might be cluttered when the printed output is smaller. Likewise, the relative position of multiple axes can appear different when printed. This function resizes the figure to the printed size.

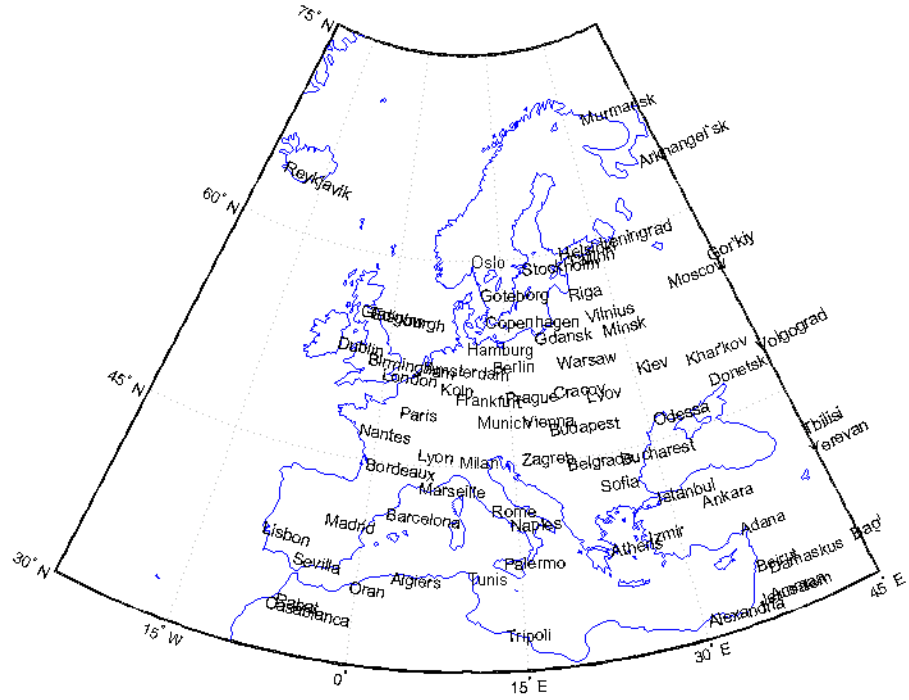
Tips

`previewmap` changes the size of the current figure to match the printed output. If the resulting figure size exceeds the screen size, the figure is enlarged as much as possible.

Examples

Is the text small enough to avoid overlapping in a map of Europe?

```
figure
worldmap europe
land=shaperead('landareas.shp','UseGeoCoords',true);
geoshow([land.Lat],[land.Lon])
m=gcm;
latlim = m.maplatlimit;
lonlim = m.maplonlimit;
BoundingBox = [lonlim(1) latlim(1);lonlim(2) latlim(2)];
cities=shaperead('worldcities.shp', ...
   'BoundingBox',BoundingBox,'UseGeoCoords',true);
for index=1:numel(cities)
   h=textm(cities(index).Lat, cities(index).Lon, ...
           cities(index).Name);
   trimcart(h)
   rotatetext(h)
end
orient landscape
tightmap
axis off
previewmap
```



Limitations

The figure cannot be made larger than the screen.

See Also

`pagesetupdlg` | `paperscale` | `axesscale`

Purpose

Project displayed map graphics object

Syntax

```
project(h)
project(h,'xy')
project(h,'yx')
```

Description

`project(h)` takes unprojected objects with handles `h` that are displayed on map axes and projects them. For example, `project` takes a line created on a map axes with the `plot` function and projects it as though it had been created with the `plotm` function. This can be useful if a standard MATLAB function was accidentally executed. The map structure of the existing map axes determines the specifics of the projection. If `h` is the handle of the map axes, then all the children of `h` are projected. Do not attempt this if any children of `h` have already been projected!

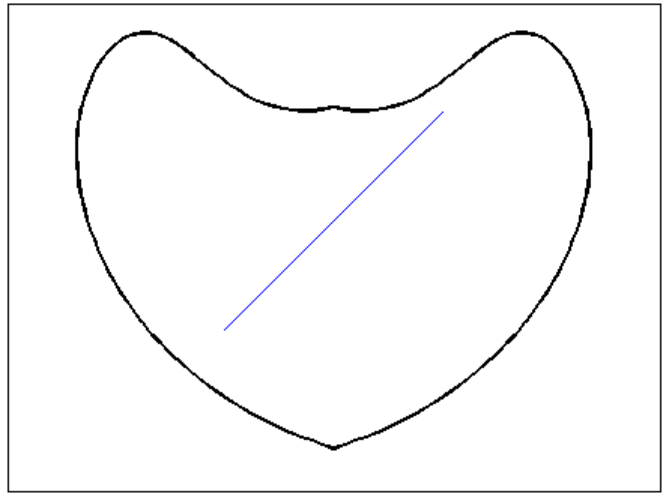
`project(h,'xy')` specifies that the `XData` of the unprojected objects corresponds to longitudes and the `YData` to latitudes. This is the default assumption.

`project(h,'yx')` specifies that the `XData` of the unprojected objects corresponds to latitudes and the `YData` to longitudes.

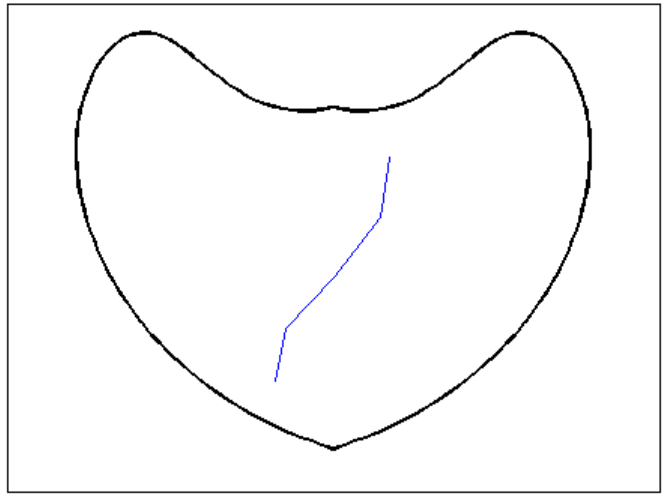
Examples

Create an axes, plot a line, then project it:

```
axesm('bonne','AngleUnits','radians');framem;
h = plot([-1 -.5 0 .5 1],[-1 -.5  0 .5 1]);
```



```
project(h)
```



The line is straight in *x*-*y* space, but when converted to a projected map object, it bends with the projection.

See Also

`linem` | `patchm` | `surfacem` | `textm`

projfwd

Purpose

Forward map projection using PROJ.4 map projection library

Syntax

```
[x,y] = projfwd(proj,lat,lon)
```

Description

`[x,y] = projfwd(proj,lat,lon)` returns the `x` and `y` map coordinates from the forward projection transformation. `proj` is a structure defining the map projection. `proj` can be an mstruct or a GeoTIFF `info` structure. `lat` and `lon` are arrays of the latitude and longitude coordinates.

For a complete list of GeoTIFF `info` and map projection structures that you can use with `projinv`, see the reference page for `projlist`.

Input Arguments

proj - defines map projections

map projection `mstruct` | GeoTiff `info` structure

Data Types
struct

lat - Latitude values

array

Latitude values specified as a array in units of degrees.

Data Types
single | double

lon - Longitude values

array

Longitude values specified as an array in units of degrees.

Data Types
single | double

Output Arguments

x - map x-coordinate

vector

X-coordinate of map returned as a vector of doubles.

y - map y-coordinate

vector

Y-coordinate of map returned as a vector of doubles.

Examples

Overlay the boundary of Massachusetts on an orthophoto of Boston

Read vector data for state boundary of Massachusetts (in latitude and longitude):

```
S = shaperead('usastatehi', 'UseGeoCoords', true, ...
    'Selector',{@(name) strcmpi(name,'Massachusetts'), 'Name'});
```

Obtain the projection structure for the orthophoto and project the state boundary vectors to it (Massachusetts State Plane coordinate system, U.S. Survey Feet):

```
proj = geotiffinfo('boston.tif');
lat = [S.Lat];
lon = [S.Lon];
[x, y] = projfwd(proj, lat, lon);
```

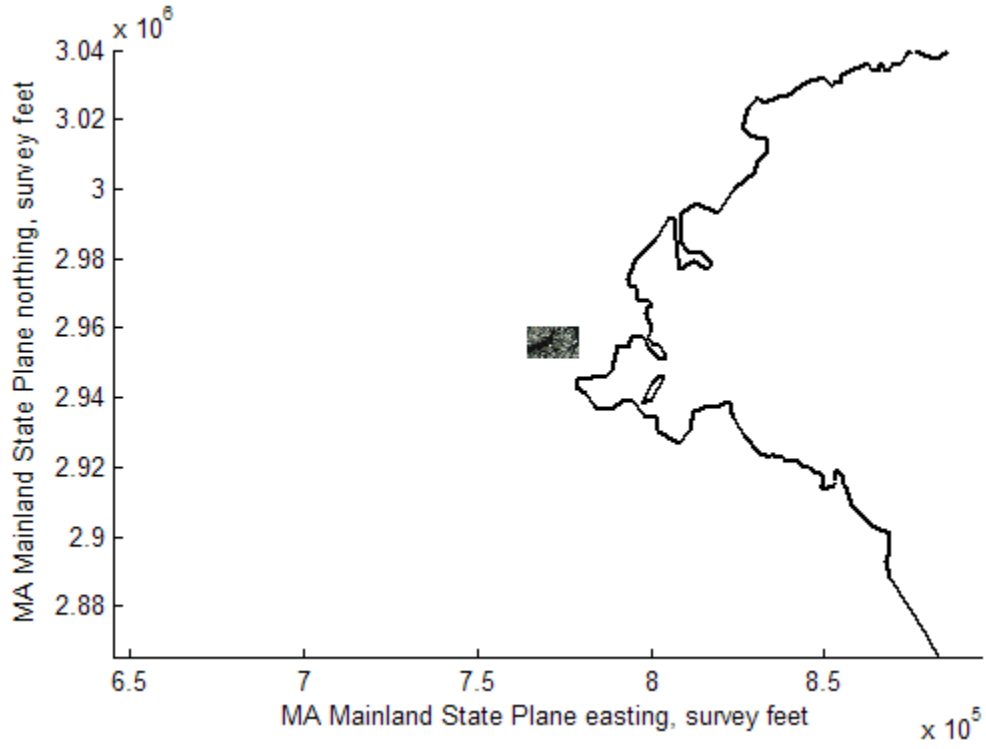
Read and display the `'boston.tif'` orthophoto image:

```
[RGB, R, bbox] = geotiffread('boston.tif');
figure
mapshow(RGB, R)
xlabel('MA Mainland State Plane easting, survey feet')
ylabel('MA Mainland State Plane northing, survey feet')
```

Overlay the state boundary and set map limits to show a little more detail:

```
hold on
mapshow(gca, x, y,'Color','black','LineWidth',2.0)
set(gca,'XLim', [ 645000,  895000], ...
        'YLIm', [2865000, 3040000]);
```

boston.tif image copyright © GeoEye, all rights reserved.



See Also

`geotiffinfo` | `mfwdtran` | `minvtran` | `projinv` | `projlist`

Purpose

Inverse map projection using PROJ.4 map projection library

Syntax

```
[lat,lon] = projinv(proj,x,y)
```

Description

`[lat,lon] = projinv(proj,x,y)` returns the latitude and longitude values from the inverse projection transformation. `proj` is a structure defining the map projection. `proj` can be a map projection mstruct or a GeoTIFF `info` structure. `x` and `y` are *x*-*y* map coordinate arrays. For a complete list of GeoTIFF `info` and map projection structures that you can use with `projinv`, see the reference page for `projlist`.

Input Arguments

proj - defines map projections

map projection `mstruct` | GeoTiff `info` structure

Data Types
struct

x - X-coordinate values

vector

X-coordinate values of map specified as an array of single or doubles.

Data Types
single | double

y - Y-coordinate values

array

Y-coordinate values of map specified as an array of single or double.

Data Types
single | double

Output Arguments

lat - Latitude values

vector

Latitude values returned as a vector of doubles.

lon - Longitude values

vector

Latitude values returned as a vector of doubles.

Examples

Display Boston Orthophoto on a Mercator projection

1 Import the Boston roads from the shapefile and obtain the projection structure from the `'boston.tif'` orthophoto:

```
roads = shaperead('boston_roads.shp');
proj = geotiffinfo('boston.tif');
```

2 Convert the road coordinates to the projection's length unit. As shown by the `UOMLength` field of the projection structure, the units of length in the projected coordinate system is `US Survey Feet`. Coordinates in the roads shapefile are in meters:

```
proj.UOMLength

ans =
US survey foot

x = [roads.X] * unitsratio('survey feet','meter');
y = [roads.Y] * unitsratio('survey feet','meter');

% Now convert the scaled coordinates of the roads
% to latitude and longitude.
[roadsLat, roadsLon] = projinv(proj, x, y);
```

3 Read the `boston_ovr.jpg` image and worldfile:

```
RGB = imread('boston_ovr.jpg');
R = worldfileread(getworldfilename('boston_ovr.jpg'));
```

4 Read state boundary vectors for Massachusetts from the `usastatehi` shapefile using a selector to eliminate other states:

```
S = shaperead('usastatehi', 'UseGeoCoords', true, ...
```

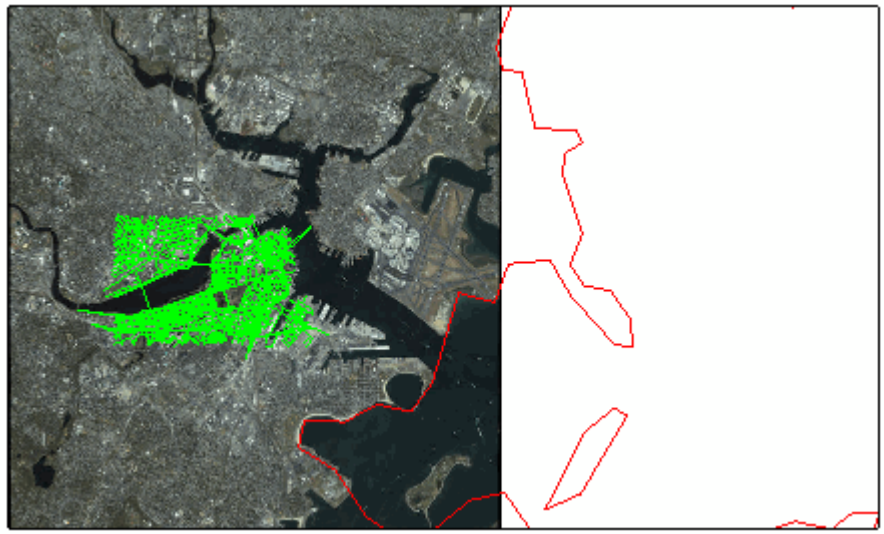
```
    'Selector',{@(name) strcmpi(name,'Massachusetts'), 'Name'});
```

5 Open a figure with a Mercator projection and display the state boundary, image, and roads:

```
figure
axesm('mercator')

geoshow(S.Lat, S.Lon, 'Color','red')
geoshow(RGB, R)
geoshow(roadsLat, roadsLon, 'Color', 'green')
```

6 Set the map boundary to the image's northern, western, and southern limits, and the eastern limit of the state boandary within the image latitude bounding box:

```
[lon, lat] = mapoutline(R, size(RGB(:,:,1)));
ltvals = find((S.Lat>=min(lat(:))) & (S.Lat<=max(lat(:))));
setm(gca,'maplonlimit',[min(lon(:)) max(S.Lon(ltvals))], ...
         'maplatlimit',[min(lat(:)) max(lat(:))])
tightmap
```



boston_ovr.jpg image copyright © GeoEye, all rights reserved.

See Also

`geotiffinfo` | `mfwdtran` | `minvtran` | `projfwd` | `projlist`

Purpose

Map projections supported by `projfwd` and `projinv`

Syntax

```
projlist(listmode)
S = projlist(listmode)
```

Description

`projlist(listmode)` displays a table of projection names, IDs, and availability. *`listmode`* is a string with value '`mapprojection`', '`geotiff`', '`geotiff2mstruct`', or '`all`'. The default value is '`mapprojection`'.

`S = projlist(listmode)` returns a structure array containing projection names, IDs, and availability. The output of `projlist` for each *`listmode`* is described below:

- `mapprojection` — Lists the map projection IDs that are available for use with `projfwd` and `projinv`. The output structure contains the fields
  - `Name` — Projection name
  - `MapProjection` — Projection ID string
- `geotiff` — Lists the GeoTIFF projection IDs that are available for use with `projfwd` and `projinv`. The output structure contains the fields
  - `GeoTIFF` — GeoTIFF projection ID string.
  - `Available`— Logical array with values 1 or 0
- `geotiff2mstruct` — Lists the GeoTIFF projection IDs that are available for use with `geotiff2mstruct`. The output structure contains the fields
  - `GeoTIFF` — GeoTIFF projection ID string
  - `MapProjection` — Projection ID string
- `all` — Lists the map and GeoTIFF projection IDs that are available for use with `projfwd` and `projinv`. The output structure contains the fields
  - `GeoTIFF` — GeoTIFF projection ID string

- `MapProjection` — Projection ID string
- `info` — Logical array with values 1 or 0
- `mstruct` — Logical array with values 1 or 0

Tips

`projfwd` and `projinv` can be used to process certain forward or inverse map projections. These functions are implemented in C using the `PROJ.4` library. `projlist` provides a convenient list of the projections that can be used with `projfwd` or `projinv`. Because `projfwd` and `projinv` accept either a map projection structure (mstruct) or a GeoTIFF info structure, `projlist` provides separate lists for each case. It can also list the projections for which a GeoTIFF info structure can be converted to an mstruct.

Examples

```
s=projlist

s =
1x19 struct array with fields:
    Name
    MapProjection

s=projlist('geotiff2mstruct')

s =
1x19 struct array with fields:
    GeoTIFF
    MapProjection
```

See Also

`geotiff2mstruct` | `projfwd` | `projinv` | `maplist` | `maps`

Purpose

Origin vector to place north pole at specified point

Syntax

```
origin = putpole(pole)
origin = putpole(pole,units)
```

Description

`origin = putpole(pole)` returns an `origin` vector required to transform a coordinate system in such a way as to put the true North Pole at a point specified by the three- (or two-) element vector `pole`. This vector is of the form `[latitude longitude meridian]`, specifying the coordinates in the original system at which the true North Pole is to be placed in the transformed system. The meridian is the longitude upon which the new system is to be centered, which is the new pole longitude if omitted. The output is a three-element vector of the form `[latitude longitude orientation]`, where the latitude and longitude are the coordinates in the untransformed system of the new origin, and the orientation is the azimuth of the true North Pole in the transformed system.

`origin = putpole(pole,units)` allows the specification of the angular units of the `origin` vector, where *`units`* is any valid angle units string. The default is `'degrees'`.

Tips

When developing transverse or oblique projections, you need transformed coordinate systems. One way to define these systems is to establish the point in the original (untransformed) system that will become the new (transformed) origin.

Examples

Pull the North Pole down the 0º meridian by 30º to 60ºN. What is the resulting origin vector?

```
origin = putpole([60 0])

origin =
   30.0000         0         0
```

This makes sense: when the pole slid down 30º, the point that was 30º north of the origin slid down to become the origin. Following is a less obvious transformation:

```
origin = putpole([60 80 0])   % constrain to original central
                              % meridian

origin =
    4.9809         0   29.6217

origin = putpole([60 80 40])  % constrain to arbitrary meridian

origin =
    4.9809   40.0000   29.6217
```

See Also

neworig | org2pol

Purpose

Project 3-D quiver plot on map axes

Syntax

```
h = quiver3m(lat,lon,alt,u,v,w)
h = quiver3m(lat,lon,alt,u,v,w,linespec)
h = quiver3m(lat,lon,alt,u,v,w,linespec,'filled')
h = quiver3m(lat,lon,alt,u,v,w,scale)
h = quiver3m(lat,lon,alt,u,v,w,linespec,scale)
h = quiver3m(lat,lon,alt,u,v,w,linespec,scale,'filled')
```

Description

`h = quiver3m(lat,lon,alt,u,v,w)` displays *velocity* vectors with components `(u,v,w)` at the geographic points `(lat,lon)` and altitude `alt` on a displayed map axes. The inputs `u`, `v`, and `w` determine the direction of the vectors in latitude, longitude, and altitude, respectively. The function automatically determines the length of these vectors to make them as long as possible without overlap. The object handles of the displayed vectors can be returned in `h`.

`h = quiver3m(lat,lon,alt,u,v,w,linespec)` allows the control of the line specification of the displayed vectors with a *`linespec`* string recognized by the MATLAB `line` function. If symbols are indicated in *`linespec`*, they are plotted at the start points of the vectors, i.e., the input points (`lat`,`lon`,`alt`).

`h = quiver3m(lat,lon,alt,u,v,w,linespec,'filled')` results in the filling in of any symbols specified by *`linespec`*.

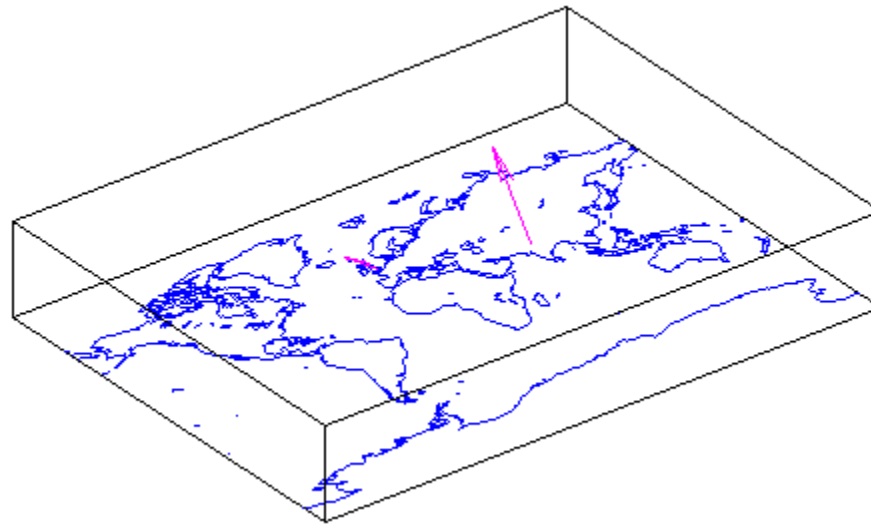
`h = quiver3m(lat,lon,alt,u,v,w,scale)`, `h = quiver3m(lat,lon,alt,u,v,w,linespec,scale)` and `h = quiver3m(lat,lon,alt,u,v,w,linespec,scale,'filled')` alter the automatically calculated vector lengths by multiplying them by the scalar value `scale`. For example, if `scale` is 2, the displayed vectors are twice as long as they would be if `scale` were 1 (the default). When scale is set to 0, the automatic scaling is suppressed and the length of the vectors is determined by the inputs. In this case, the vectors are plotted from (`lat`,`lon`,`alt`) to (`lat+u`,`lon+v`,`alt+w`).

Examples

Plot 3-D quiver vectors from London (51.5ºN,0º) and New Delhi (29ºN,77.5ºE), both at an altitude of 0. Suppress the automatic scaling.

Terminate both vectors at an altitude of 1; the London vector should terminate 100º southward and 70º eastward, while the New Delhi vector should terminate 50º northward and 10º eastward.

```
load coast
axesm miller; view(3)
plotm(lat,long)
lat0 = [51.5,29]; lon0 = [0 77.5]; alt = [0 0];
u = [-40 50]; v = [-70 10]; w = [1 1];
quiver3m(lat0,lon0,alt,u,v,w,'m')
tightmap
```



See Also

`quiverm` | `quiver3`

Purpose

Project 2-D quiver plot on map axes

Syntax

```
h = quiverm(lat,lon,u,v)
h = quiverm(lat,lon,u,v,linespec)
h = quiverm(lat,lon,u,v,linespec,'filled')
h = quiverm(lat,lon,u,v,scale)
h = quiverm(lat,lon,u,v,...linespec,scale,'filled')
```

Description

`h = quiverm(lat,lon,u,v)` displays *velocity* vectors with components `(u,v)` at the geographic points `(lat,lon)` on displayed map axes. All four inputs should be in the `AngleUnits` of the map axes. The inputs `u` and `v` determine the direction of the vectors in latitude and longitude, respectively. The function automatically determines the length of these vectors to make them as long as possible without overlap. The object handles of the displayed vectors can be returned in `h`.

`h = quiverm(lat,lon,u,v,linespec)` allows the control of the line specification of the displayed vectors with a *`linespec`* string recognized by the MATLAB `line` function. If symbols are indicated in *`linespec`*, they are plotted at the start points of the vectors, i.e., the input points (`lat`,`lon`).

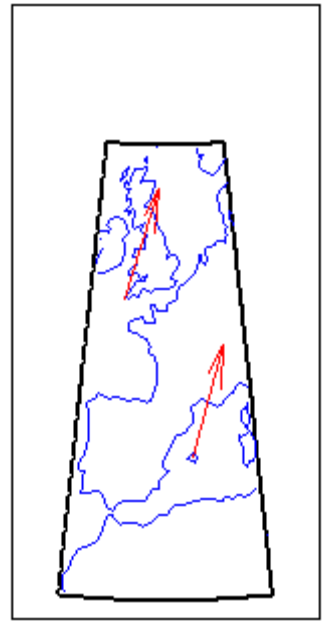
`h = quiverm(lat,lon,u,v,linespec,'filled')` results in the filling in of any symbols specified by *`linespec`*.

`h = quiverm(lat,lon,u,v,scale)` and `h = quiverm(lat,lon,u,v,...linespec,scale,'filled')` alter the automatically calculated vector lengths by multiplying them by the scalar value `scale`. For example, if `scale` is 2, the displayed vectors are twice as long as they would be if `scale` were 1 (the default). When scale is set to 0, the automatic scaling is suppressed, and the length of the vectors is determined by the inputs. In this case, the vectors are plotted from (`lat`,`lon`) to (`lat+u`,`lon+v`).

Examples

Plot quiver vectors from Land's End (50ºN,5.4ºW) and Majorca (39.7ºN,2.9ºE) in a direction corresponding to +5º latitude and +3º longitude. Use automatic scaling.

```
load coast
axesm('eqaconic','MapLatLimit',[30 60],'MapLonLimit',[-10 10])
framem; plotm(lat,long)
lat0 = [50 39.7]; lon0 = [-5.4 2.9];
u = [5 5]; v = [3 3];
quiverm(lat0,lon0,u,v,'r')
```



See Also

quiver3m | quiver

Purpose

Convert distance from radians to kilometers

Syntax

```
km = rad2km(rad)
km = rad2km(rad,radius)
km = rad2km(rad,sphere)
```

Description

`km = rad2km(rad)` converts distances from radians to kilometers as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`km = rad2km(rad,radius)` converts distances from radians to kilometers as measured along a great circle on a sphere having the specified radius. `radius` must be in units of kilometers.

`km = rad2km(rad,sphere)` converts distances from radians to kilometers, as measured along a great circle on a sphere approximating an object in the Solar System. *`sphere`* may be one of the following strings: `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'earth'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, or `'pluto'`, and is case-insensitive.

See Also

`km2rad` | `degtorad` | `radtodeg` | `deg2km` | `km2deg` | `km2nm` | `km2sm` | `deg2nm` | `nm2rad` | `nm2km` | `nm2sm` | `deg2sm` | `sm2rad` | `sm2km` | `sm2nm`

radtodeg

Purpose

Convert angles from radians to degrees

Syntax

```
angleInDegrees = radtodeg(angleInRadians)
```

Description

`angleInDegrees = radtodeg(angleInRadians)` converts angle units from radians to degrees. This is both an angle conversion function and a distance conversion function, because arc length can be a measure of distance in either radians or degrees (provided the radius is known).

Examples

There are 180º in π radians:

```
anglout = radtodeg(pi)

anglout =
   180
```

See Also

`degtorad` | `fromDegrees` | `fromRadians` | `toDegrees` | `toRadians`

Purpose

Convert distance from radians to nautical miles

Syntax

```
nm = rad2nm(rad)
nm = rad2nm(rad,radius)
nm = rad2nm(rad,sphere)
```

Description

`nm = rad2nm(rad)` converts distances from radians to nautical miles as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`nm = rad2nm(rad,radius)` converts distances from radians to nautical miles as measured along a great circle on a sphere having the specified radius. `radius` must be in units of nautical miles.

`nm = rad2nm(rad,sphere)` converts distances from radians to nautical miles, as measured along a great circle on a sphere approximating an object in the Solar System. *`sphere`* may be one of the following strings: `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'earth'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, or `'pluto'`, and is case-insensitive.

See Also

`km2rad` | `degtorad` | `radtodeg` | `deg2km` | `km2deg` | `km2nm` | `km2sm` | `deg2nm` | `nm2rad` | `nm2km` | `nm2sm` | `deg2sm` | `sm2rad` | `sm2km` | `sm2nm`

rad2sm

Purpose

Convert distance from radians to statute miles

Syntax

```
sm = rad2sm(rad)
sm = rad2sm(rad,radius)
sm = rad2sm(rad,sphere)
```

Description

`sm = rad2sm(rad)` converts distances from radians to statute miles as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`sm = rad2sm(rad,radius)` converts distances from radians to statute miles as measured along a great circle on a sphere having the specified radius. `radius` must be in units of statute miles.

`sm = rad2sm(rad,sphere)` converts distances from radians to statute miles, as measured along a great circle on a sphere approximating an object in the Solar System. *`sphere`* may be one of the following strings: `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'earth'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, or `'pluto'`, and is case-insensitive.

Examples

How long is a trip around the equator in statute miles?

```
sm = rad2sm(2*pi)

sm =
   2.4874e+04
```

How about on Jupiter?

```
sm = rad2sm(2*pi,'jupiter')

sm =
   2.7283e+005
```

See Also

`km2rad` | `degtorad` | `radtodeg` | `deg2km` | `km2deg` | `km2nm` | `km2sm` | `deg2nm` | `nm2rad` | `nm2km` | `nm2sm` | `deg2sm` | `sm2rad` | `sm2km` | `sm2nm`

Purpose

Ellipsoidal radii of curvature

Syntax

```
r = rcurve(ellipsoid,lat)
r = rcurve('parallel',ellipsoid,lat)
r = rcurve('meridian',ellipsoid,lat)
r = rcurve('transverse',ellipsoid,lat)
r = rcurve(..., angleunits)
```

Description

`r = rcurve(ellipsoid,lat)` and `r = rcurve('parallel',ellipsoid,lat)` return the parallel radius of curvature at the latitude `lat` for a reference ellipsoid defined by `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. `r` is in units of length consistent with those used for the semimajor axis. `lat` is in `` `degrees' ``.

`r = rcurve('meridian',ellipsoid,lat)` returns the meridional radius of curvature, which is the radius of curvature in the plane of a meridian at the latitude `lat`.

`r = rcurve('transverse',ellipsoid,lat)` returns the transverse radius of curvature, which is the radius of a curvature in a plane normal to the surface of the ellipsoid and normal to a meridian, at the latitude `lat`.

`r = rcurve(..., angleunits)` specifies the units of the input `lat`. `angleunits` can be `` `degrees' `` or `` `radians' ``.

Examples

The radii of curvature of the default ellipsoid at 45º, in kilometers:

```
r = rcurve('transverse',referenceEllipsoid('earth','km'),...
           45,'degrees')

r =
   6.3888e+03

r = rcurve('meridian',referenceEllipsoid('earth','km'),...
           45,'degrees')
```

```
r =
   6.3674e+03

r = rcurve('parallel',referenceEllipsoid('earth','km'),...
           45,'degrees')

r =
   4.5024e+03
```

See Also

rsphere

Purpose

Read fields or records from fixed-format files

Syntax

```
struc = readfields(fname,fstruc)
struc = readfields(fname,fstruc,recordIDs)
struc = readfields(fname,fstruc,fieldIDs)
struc = readfields(fname,fstruc,recordIDs,mformat)
struc = readfields(fname,fstruc,recordIDs,mformat,fid)
struc = readfields(fname,fstruc,recordIDs,mformat,fid,
   'sparse')
```

Description

`struc = readfields(fname,fstruc)` reads all the records from a fixed format file. *`fname`* is a string containing the name of the file. If it is empty, the file is selected interactively. `fstruc` is a structure defining the format of the file. The contents of `fstruc` are described below. The result is returned in a structure.

`struc = readfields(fname,fstruc,recordIDs)` reads only the records specified in the vector `recordIDs`. For example, `recordIDs = [1 2 3 4]`. All the fields in the selected records are read.

`struc = readfields(fname,fstruc,fieldIDs)` reads only the fields specified in the cell array `fieldIDs`. For example, `fieldIDs = {1 2 4}`. The selected fields are read from all the records. `fieldIDs` can be used in place of `recordIDs` in all calling forms.

`struc = readfields(fname,fstruc,recordIDs,mformat)` opens the file with the specified machine format. *`mformat`* must be recognized by `fopen`.

`struc = readfields(fname,fstruc,recordIDs,mformat,fid)` reads from a file that is already open. `fid` is the file identifier returned by `fopen`. The records are read starting from the current location in the file.

`struc = readfields(fname,fstruc,recordIDs,mformat,fid,'sparse')` disables error messages when the number of elements read does not agree with the stated format of the file. This is useful for formatted files

with empty fields. Use `fid = []` for files that are not already open. This option is only compatible with reading selected records.

Background

Map data is often provided as binary or ASCII files with a fixed format. Writing your own functions to read the data into the MATLAB workspace can be difficult and time-consuming, particularly for binary files. This function allows you to read the data by simply specifying the format of the file.

Examples

Write a binary file and read it.

```
fid = fopen('testbin','wb');
for i = 1:3
 fwrite(fid,['character' num2str(i) ],'char');
 fwrite(fid,i,'int8');
 fwrite(fid,[i i],'int16');
 fwrite(fid,i,'integer*4');
 fwrite(fid,i,'real*8');
end
fclose(fid);

fs(1).length = 10;fs(1).type = 'char';fs(1).name = 'field 1';
fs(2).length = 1;fs(2).type = 'int8'; fs(2).name = 'field 2';
fs(3).length = 2;fs(3).type = 'int16';fs(3).name = 'field 3';
fs(4).length = 1;fs(4).type = 'integer*4';fs(4).name = 'field 4';
fs(5).length = 1;fs(5).type = 'float64'; fs(5).name = 'field 5';

s = readfields('testbin',fs);

s(1)
ans =
    field1: 'character1'
    field2: 1
    field3: [1 1]
    field4: 1
    field5: 1
```

Limitations

Formatted numbers must stay within the width specified for them. Files must have a size that is an integer multiple of the computed record length. This is potentially a problem for formatted files on DOS platforms that use a carriage return/linefeed line ending everywhere except the last record. File sizes are not checked when an open file is provided.

Tips

The format of the file is described in the input argument `fstruc`. `fstruc` is a structure with one entry for every field in the file. `fstruc` has three required fields: `length`, `name`, and `type`. For fields containing binary data of the type that would be read by `fread`, `length` is the number of elements to be read, `name` is a string containing the field name under which the read data is stored in the output structure, and `type` is a format string recognized by `fread`. Repetition modifiers such as `'40*char'` are *not* supported. Fields with empty field names are omitted from the output.

The following `fstruc` definition is for a file with a 40-character field, a field containing two integers, and a field with a single-precision floating-point number.

```
fstruc(1).length = 40;
fstruc(1).name = 'character Field'; % spaces will be suppressed
filestruc(1).type = 'char';

fstruc(2).length = 2;
fstruc(2).name = 'integer Field';   % spaces will be suppressed
fstruc(2).type = 'int16';

fstruc(3).length = 1;
fstruc(3).name = 'float Field';     % spaces will be suppressed
fstruc(3).type = 'real*4';
```

The type can also be a `fscanf` and `sscanf`-style format string of the form `'%nX'`, where `n` is the number of characters within which the formatted data is found, and `X` is the conversion character such as `'g'` or `'d'`. For formatted fields, the length entry in `fstruc` is the number of elements, each of which has the width specified in the type string. Fortran-style

double-precision output such as `'0.0D00'` can be read using a type string such as `'%nD'`, where `n` is the number of characters per element. This is an extension to the C-style format strings accepted by `sscanf`. Users unfamiliar with C should note that `'%d'` is preferred over `'%i'` for formatted integers. MATLAB syntax follows C in interpreting `'%i'` integers with leading zeros as octal. Line-ending characters in ASCII files must also be counted in the `fstruc` specification. Note that the number of line-ending characters differs across platforms.

A field specification for a formatted field with two integers each six characters wide would be of the form

```
fstruc(4).length = 2;
fstruc(4).name = 'Elevation Units';
fstruc(4).type = '%6d'
```

To summarize, `length` is the number of elements for binary numbers, the number of characters for strings, and the number of elements for formatted data.

You can omit fields from all output by providing an empty string for the `fstruc` name field.

See Also

`grepfields` | `readmtx` | `textread` | `spcread` | `dlmread`

Purpose

Read Fifth Fundamental Catalog of Stars

Syntax

```
struc = readfk5(filename)
struc = readfk5(filename,struc)
```

Description

`struc = readfk5(filename)` reads the FK5 file and returns the contents in a structure. Each star is an element in the structure, with the different data items stored in appropriately named fields.

`struc = readfk5(filename,struc)` appends the data in the file to the existing structure `struc`.

Background

The Fifth Fundamental Catalog of Stars (FK5), Parts I and II, is a compilation of data on more than 4500 stars. The catalog contains positions, errors in positions, proper motions, and characteristics such as magnitudes, spectral types, parallaxes, and radial velocities. There are also cross-references to the identities of stars in other catalogs. It was compiled by researchers at the Astronomisches Rechen-Institut in Heidelberg.

Tips

Positions are given in terms of right ascension and declination. “Projections and Parameters” in the Concepts section of the Mapping Toolbox documentation shows how to convert these to latitude and longitude for display by the toolbox.

The Fifth Fundamental Catalog of Stars (FK5), Parts I and II data and documentation are available over the Internet by anonymous ftp.

Examples

```
FK5 = readfk5('FK5.dat');
FK5e = readfk5('FK5_ext.dat');
whos

  Name       Size          Bytes  Class
  FK5        1x1535      5042752  struct array
  FK5e       1x3117     10226424  struct array
FK5e(1)
```

```
ans =
          FK5: 2003
          RAh: 0
          RAm: 5
          RAs: 1.1940
        pmRA: 0.6230
          DEd: 27
          DEm: 40
          DEs: 29.0100
        pmDE: -1.1100
     RAh1950: 0
     RAm1950: 2
     RAs1950: 26.5900
    pmRA1950: 0.6210
     DEd1950: 27
     DEm1950: 23
     DEs1950: 47.4400
    pmDE1950: -1.1100
    EpRA1900: 51.7200
       e_RAs: 2
     e_pmRA: 9
    EpDE1900: 46.8200
       e_DEs: 3.4000
     e_pmDE: 14
       Vmag: 6.4700
     n_Vmag: ''
     SpType: 'G5'
        plx: []
         RV: 12
     AGK3R: '38'
        SRS: ''
         HD: '225292'
         DM: 'BD+26 4744'
         GC: '48'
```

References

See references [5] and [6] in the Bibliography located at the end of this chapter.

See Also

dms2degrees | scatterm

Purpose

Read matrix stored in file

Syntax

```
mtx = readmtx(fname,nrows,ncols,precision)
mtx =
readmtx(fname,nrows,ncols,precision,readrows,readcols)
mtx = readmtx(fname,nrows,ncols,precision,... readrows,
   readcols,mformat)
mtx = readmtx(fname,nrows,ncols,precision,... readrows,
   readcols,mformat,nheadbytes)
mtx = readmtx(fname,nrows,ncols,precision,... readrows,
   readcols,mformat,nheadbytes,nRowHeadBytes)
mtx = readmtx(fname,nrows,ncols,precision,... readrows,

readcols,mformat,nheadbytes,nRowHeadBytes,nRowTrailBytes)
mtx = readmtx(fname,nrows,ncols,precision,... readrows,
   readcols,mformat,nheadbytes,nRowHeadBytes,
   ... nRowTrailBytes,nFileTrailBytes)
mtx = readmtx(fname,nrows,ncols,precision,... readrows,
   readcols,mformat,nheadbytes,nRowHeadBytes,
   ... nRowTrailBytes,nFileTrailBytes,recordlen)
```

Description

`mtx = readmtx(fname,nrows,ncols,precision)` reads a matrix stored in a file. The file contains only a matrix of numbers with the dimensions `nrows` by `ncols` stored with the specified *`precision`*. Recognized *`precision`* strings are described below.

`mtx = readmtx(fname,nrows,ncols,precision,readrows,readcols)` reads a subset of the matrix. `readrows` and `readcols` specify which rows and columns are to be read. They can be vectors containing the row or column numbers, or two-element vectors of the form `[start end]`, which are expanded using the colon operator to `start:end`. To read just two rows or columns, without expansion by the colon operator, provide the indices as a column matrix.

`mtx = readmtx(fname,nrows,ncols,precision,... readrows,readcols,mformat)` specifies the machine format used to write the file. *`mformat`* can be any string recognized by `fopen`. This

option is used to automatically swap bytes for files written on platforms with a different byte ordering.

`mtx = readmtx(`*`fname`*`,nrows,ncols,`*`precision`*`,...
readrows,readcols,`*`mformat`*`,nheadbytes)` skips the file header, whose length is specified in bytes.

`mtx = readmtx(`*`fname`*`,nrows,ncols,`*`precision`*`,...
readrows,readcols,`*`mformat`*`,nheadbytes,nRowHeadBytes)` also skips a header that precedes every row of the matrix. The length of the header is specified in bytes.

`mtx = readmtx(`*`fname`*`,nrows,ncols,`*`precision`*`,...
readrows,readcols,`*`mformat`*`,nheadbytes,nRowHeadBytes,nRowTrailBytes)` also skips a trailer that follows every row of the matrix. The length of the trailer is specified in bytes.

`mtx = readmtx(`*`fname`*`,nrows,ncols,`*`precision`*`,...
readrows,readcols,`*`mformat`*`,nheadbytes,nRowHeadBytes,...
nRowTrailBytes,nFileTrailBytes)` accounts for the length of data following the matrix. The sizes of the components of the matrix are used to compute an expected file size, which is compared to the actual file size.

`mtx = readmtx(`*`fname`*`,nrows,ncols,`*`precision`*`,...
readrows,readcols,`*`mformat`*`,nheadbytes,nRowHeadBytes,...
nRowTrailBytes,nFileTrailBytes,recordlen)` overrides the record length calculated from the precision and number of columns, and instead uses the record length given in bytes. This is used for formatted data with extra spaces or line breaks in the matrix.

Background

Map data is often provided as binary or ASCII files with a fixed format. Writing your own functions to read the data into the MATLAB workspace can be difficult and time-consuming, particularly for binary files. This function allows you to read the data by simply specifying the format of the file.

Examples

Write and read a binary matrix file:

```
fid = fopen('binmat','w');
fwrite(fid,1:100,'int16');
fclose(fid);
mtx = readmtx('binmat',10,10,'int16')

mtx =
     1     2     3     4     5     6     7     8     9    10
    11    12    13    14    15    16    17    18    19    20
    21    22    23    24    25    26    27    28    29    30
    31    32    33    34    35    36    37    38    39    40
    41    42    43    44    45    46    47    48    49    50
    51    52    53    54    55    56    57    58    59    60
    61    62    63    64    65    66    67    68    69    70
    71    72    73    74    75    76    77    78    79    80
    81    82    83    84    85    86    87    88    89    90
    91    92    93    94    95    96    97    98    99   100

mtx = readmtx('binmat',10,10,'int16',[2 5],3:2:9)

mtx =
    13    15    17    19
    23    25    27    29
    33    35    37    39
    43    45    47    49
```

Limitations

Every row of the matrix must have the same number of elements.

Tips

This function reads files that have a general format consisting of a header, a matrix, and a trailer. Each row of the matrix can have a certain number of bytes of extraneous information preceding or following the matrix data.

Both binary and formatted data files can be read. If the file is binary, the precision argument is a format string recognized by `fread`. Repetition modifiers such as `'40*char'` are *not* supported. If the file is formatted, precision is a `fscanf` and `sscanf`-style format string of

the form `'%nX'`, where `n` is the number of characters within which the formatted data is found, and `X` is the conversion character such as `'g'` or `'d'`. Fortran-style double-precision output such as `'0.0D00'` can be read using a precision string such as `'%nD'`, where `n` is the number of characters per element. This is an extension to the C-style format strings accepted by `sscanf`. Users unfamiliar with C should note that `'%d'` is preferred over `'%i'` for formatted integers. MATLAB syntax follows C in interpreting `'%i'` integers with leading zeros as octal. Formatted files with line endings need to provide the number of trailing bytes per row, which can be 1 for platforms with carriage returns *or* linefeed (Macintosh, UNIX), or 2 for platforms with carriage returns *and* linefeeds (DOS).

See Also

`readfields` | `textread` | `spcread` | `dlmread`

reckon

Purpose

Point at specified azimuth, range on sphere or ellipsoid

Syntax

```
[latout,lonout] = reckon(lat,lon,arclen,az)
[latout,lonout] = reckon(lat,lon,arclen,az,units)
[latout,lonout] = reckon(lat,lon,arclen,az,ellipsoid)
[latout,lonout] = reckon(lat,lon,arclen,az,ellipsoid,units)
[latout,lonout] = reckon(track,...)
```

Description

`[latout,lonout] = reckon(lat,lon,arclen,az)`, for scalar inputs, calculates a position (`latout,lonout`) at a given range, `arclen`, and azimuth, `az`, along a great circle from a starting point defined by `lat` and `lon`. `lat` and `lon` are in degrees. `arclen` must be expressed as degrees of arc on a sphere, and equals the length of a great circle arc connecting the point (`lat`, `lon`) to the point (`latout`, `lonout`). `az`, also in degrees, is measured clockwise from north. `reckon` calculates multiple positions when given four arrays of matching size. When given a combination of scalar and array inputs, the scalar inputs are automatically expanded to match the size of the arrays.

`[latout,lonout] = reckon(lat,lon,arclen,az,units)`, where *`units`* is either `'degrees'` or `'radians'`, specifies the units of the inputs and outputs, including `arclen`. The default value is `'degrees'`.

`[latout,lonout] = reckon(lat,lon,arclen,az,ellipsoid)` calculates positions along a geodesic on an ellipsoid, as specified by `ellipsoid`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The range, `arclen`, must be expressed same unit of length as the semimajor axis of the `ellipsoid`.

`[latout,lonout] = reckon(lat,lon,arclen,az,ellipsoid,units)` calculates positions on the specified ellipsoid with `lat`, `lon`, `az`, `latout`, and `lonout` in the specified angle units.

`[latout,lonout] = reckon(track,...)` calculates positions on great circles (or geodesics) if *`track`* is `'gc'` and along rhumb lines if *`track`* is `'rh'`. The default value is `'gc'`.

Examples

Find the coordinates of the point 600 nautical miles northwest of London, UK (51.5ºN,0º) in a great circle sense:

```
% Convert nm distance to degrees.
dist = nm2deg(600)
dist =
    9.9933

% Northwest is 315 degrees.
pt1 = reckon(51.5,0,dist,315)
pt1 =
   57.8999  -13.3507
```

Now, determine where a plane from London traveling on a constant northwesterly course for 600 nautical miles would end up:

```
pt2 = reckon('rh',51.5,0,dist,315)

pt2 =
   58.5663  -12.3699
```

How far apart are the points above (distance in great circle sense)?

```
separation = distance('gc',pt1,pt2)

separation =
    0.8430

% Convert answer to nautical miles.
nmsep = deg2nm(separation)
nmsep =
   50.6156
```

Over 50 nautical miles separate the two points.

See Also

azimuth | distance | km2deg | dreckon | track | track1 | track2

reducem

Purpose

Reduce density of points in vector data

Syntax

```
[latout,lonout] = reducem(latin,lonin)
[latout,lonout] = reducem(latin,lonin,tol)
[latout,lonout,cerr] = reducem(...)
[latout,lonout,cerr,tol] = reducem(...)
```

Description

`[latout,lonout] = reducem(latin,lonin)` reduces the number of points in vector map data. In this case the tolerance is computed automatically.

`[latout,lonout] = reducem(latin,lonin,tol)` uses the provided tolerance. The units of the tolerance are degrees of arc on the surface of a sphere.

`[latout,lonout,cerr] = reducem(...)` in addition returns a measure of the error introduced by the simplification. The output `cerr` is the difference in the arc length of the original and reduced data, normalized by the original length.

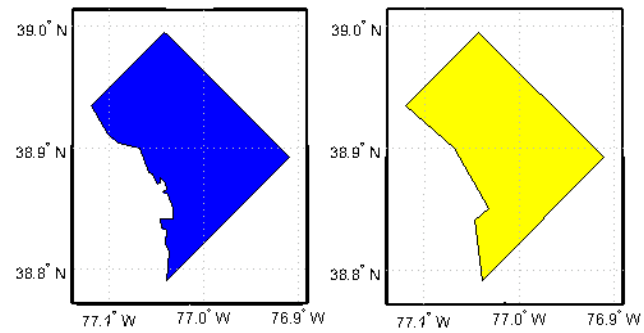
`[latout,lonout,cerr,tol] = reducem(...)` also returns the tolerance used in the reduction, which is useful when the tolerance is computed automatically.

Examples

Compare the original and reduced outlines of the District of Columbia from the `usastatehi` state outline data:

```
dc = shaperead('usastatehi',...
    'UseGeoCoords', true,...
    'Selector',{@(name) ...
     strcmpi(name,'district of columbia'), 'Name'});
lat = extractfield(dc, 'Lat')';
lon = extractfield(dc, 'Lon')';
[latreduced, lonreduced] = reducem(lat, lon);

lonlim = dc.BoundingBox(:,1)' + [-0.02 0.02];
latlim = dc.BoundingBox(:,2)' + [-0.02 0.02];
```

```
subplot(1,2,1)
usamap(latlim, lonlim); axis off
geoshow(lat, lon,...
    'DisplayType', 'polygon', 'FaceColor', 'blue')

subplot(1,2,2)
usamap(latlim, lonlim); axis off
geoshow(latreduced, lonreduced,...
    'DisplayType', 'polygon', 'FaceColor', 'yellow')
```



Tips

Vector data is reduced using the Douglas-Peucker line simplification algorithm. This method recursively subdivides a polygon until a run of points can be replaced by a straight line segment, with no point in that run deviating from the straight line by more than the tolerance. The distances used to decide on which runs of points to eliminate are computed in a Plate Carrée projection.

Reduced geographic data might not always be appropriate for display. If all intermediate points in a data set are reduced, then lines appearing straight in one projection are incorrectly displayed as straight lines in others.

See Also

`interpm` | `resizem`

referenceEllipsoid

Purpose

Reference ellipsoid

Description

A `referenceEllipsoid` is an `oblateSpheroid` object with three additional properties:

- A name string (`Name`).
- A string (`LengthUnit`) indicating the units of the semimajor and semiminor axes.
- A numeric code (`Code`) that matches an entry in the ellipsoid table of the EPSG/OGP Geodetic Parameter Dataset.

Construction

`E = referenceEllipsoid` returns a reference ellipsoid object that represents the unit sphere.

`E = referenceEllipsoid(name)` returns a reference ellipsoid object corresponding to the string, `name`. The values of the `SemimajorAxis` and `SemiminorAxis` properties are in `meters`.

`E = referenceEllipsoid(code)` returns a reference ellipsoid object corresponding to the numerical EPSG code, `code`. All of the nearly 60 codes in the EPSG ellipsoid table are supported. The unit of length used for the `SemimajorAxis` and `SemiminorAxis` properties depends on the ellipsoid selected, and is indicated in the property, `E.LengthUnit`.

`E = referenceEllipsoid(name,lengthUnit)` and `E = referenceEllipsoid(code,lengthUnit)` return the ellipsoid object with the `SemimajorAxis` and `SemiminorAxis` properties in the specified unit of length, `lengthUnit`. The `lengthUnit` can be any length unit string supported by `validateLengthUnit`.

Input Arguments

name

One of the short or long names listed in table.

DataType: String.

EPSG Code	Short Name	Long Name
—	'unitsphere'	'Unit Sphere'
7019	'grs80'	'Geodetic Reference System 1980'
7030	'wgs84'	'World Geodetic System 1984'
7015	'everest'	'Everest 1830'
7004	'bessel'	'Bessel 1841'
7001	'airy1830'	'Airy 1830'
7002	'airy1849'	'Airy Modified 1849'
7008	'clarke66'	'Clarke 1866'
7012	'clarke80'	'Clarke 1880'
7022	'international'	'International 1924'
7024	'krasovsky'	'Krasovsky 1940'
7043	'wgs72'	'World Geodetic System 1972'
—	'wgs60'	'World Geodetic System 1960'
—	'iau65'	'International Astronomical Union 1965'
—	'wgs66'	'World Geodetic System 1966'
—	'iau68'	'International Astronomical Union 1968'

EPSG Code	Short Name	Long Name
7030	'earth'	'World Geodetic System 1984'
—	'sun'	'Sun'
—	'moon'	'Moon'
—	'mercury'	'Mercury'
—	'venus'	'Venus'
—	'mars'	'Mars'
—	'jupiter'	'Jupiter'
—	'saturn'	'Saturn'
—	'uranus'	'Uranus'
—	'neptune'	'Neptune'
—	'pluto'	'Pluto'

code

Numerical EPSG code

A numerical code between 7000 and 8000 indicating a row in the EPSG ellipsoid table. All of the nearly 60 codes in the EPSG ellipsoid table are supported, in addition to the ones listed in the above table.

lengthUnit

Unit of length used for semimajor and semiminor axes.

Properties

Code

Numerical EPSG code

A numerical code between 7000 and 8000 indicating a row in the EPSG ellipsoid table.

Name

Name of the reference ellipsoid

A string naming or describing the ellipsoid, for example, 'World Geodetic System 1984'.

LengthUnit

Unit of length string for ellipsoid axes

The empty string, or any unit of length string accepted by the `validateLengthUnit` function.

SemimajorAxis

Equatorial radius of spheroid, `a`

When set to a new value, the `SemiminorAxis` property scales as needed to preserve the shape of the spheroid and the values of shape-related properties including `InverseFlattening` and `Eccentricity`.

The only way to change the `SemimajorAxis` property is to set it directly.

DataType: Positive, finite scalar.

Default: `1`

SemiminorAxis

Distance from center of spheroid to pole, `b`

The value is always less than or equal to `SemimajorAxis` property. When set to a new value, the `SemimajorAxis` property remains unchanged, but the shape of the spheroid changes, which is reflected in changes in the values of `InverseFlattening`, `Eccentricity`, and other shape-related properties.

DataType: Nonnegative, finite scalar.

Default: `1`

InverseFlattening

Reciprocal of flattening

`1/f = a/(a-b)`, where `a` and `b` are semimajor and semiminor axes. A value of `1/f = Inf` designates a perfect sphere. As `1/f` value approaches 1, the spheroid approaches a flattened disk. When set to a new value, other shape-related properties update, including `Eccentricity`. The `SemimajorAxis` value is unaffected by changes to `1/f`, but the value of the `SemiminorAxis` property adjusts to reflect the new shape.

DataType: Positive scalar in the interval `[1 Inf]`.

Default: `Inf`

Eccentricity

First eccentricity of spheroid

`ecc = sqrt(a^2-b^2)/a`. A value of 0 designates a perfect sphere. When set to a new value, other shape-related properties update, including `InverseFlattening`. The `SemimajorAxis` value is unaffected by changes to `ecc`, but the value of the `SemiminorAxis` property adjusts to reflect the new shape.

DataType: Nonnegative scalar less than or equal to 1.

Default: `0`

Flattening

Flattening of spheroid

`f = (a-b)/a`, where `a` and `b` are semimajor and semiminor axes of the spheroid.

Access: Read only

ThirdFlattening

Third flattening of spheroid

`n = (a-b)/(a+b)`, where `a` and `b` are semimajor and semiminor axes of spheroid.

Access: Read only

MeanRadius

Mean radius of spheroid, `(2*a+b)/3`

The `MeanRadius` property uses the same unit of length as the `SemimajorAxis` and `SemiminorAxis` properties.

Access: Read only

SurfaceArea

Surface area of spheroid

The `SurfaceArea` is expressed in units of area consistent with the unit of length used for the `SemimajorAxis` and `SemiminorAxis` properties.

Access: Read only

Volume

Volume of spheroid

The `Volume` is expressed in units of volume consistent with the unit of length used for the `SemimajorAxis` and `SemiminorAxis` properties.

Access: Read only

Note When you define a spheroid in terms of semimajor and semiminor axes (rather than semimajor axis and inverse flattening or semimajor axis and eccentricity), a small loss of precision in the last few digits of `f`, `ecc`, and `n` is possible. This is unavoidable, but does not affect the results of practical computation.

Methods

ecef2geodetic	Transform geocentric (ECEF) to geodetic coordinates
ecefOffset	Cartesian ECEF offset between geodetic positions
geodetic2ecef	Transform geodetic to geocentric (ECEF) coordinates

Copy Semantics

Value. To learn how value classes affect copy operations, see Copying Objects

Examples

Construct a GRS80 reference ellipsoid

Construct a GRS80 ellipsoid using `referenceEllipsoid` class.

Use the name of GRS80 ellipsoid to construct it.

```
e = referenceEllipsoid('Geodetic Reference System 1980')
```

Use EPSG code 7019 to construct the ellipsoid.

```
e = referenceEllipsoid(7019)
```

The output for both the cases is:

```
e =

  referenceEllipsoid

  Properties:
                Code: 7019
                Name: 'Geodetic Reference System 1980'
          LengthUnit: 'meter'
       SemimajorAxis: 6378137
       SemiminorAxis: 6356752.31414036
    InverseFlattening: 298.257222101
         Eccentricity: 0.0818191910428158
```

Specify Units for GRS80 ellipsoid

Specify units while constructing a GRS80 reference ellipsoid.

You can specify a unit of length while creating the ellipsoid. The unit of length is any string acceptable by the `validateLengthUnit` function.

```
e = referenceEllipsoid('GRS80','km')

e =

  referenceEllipsoid

  Properties:
                Code: 7019
                Name: 'Geodetic Reference System 1980'
          LengthUnit: 'kilometer'
       SemimajorAxis: 6378.137
       SemiminorAxis: 6356.75231414036
    InverseFlattening: 298.257222101
         Eccentricity: 0.0818191910428158
```

Construct an ellipsoid from an input file

Construct an ellipsoid based on input from a file, boston.tif.

Read the boston.tif file using geotiffinfo, which will place metadata about the ellipsoid in the field GeoTIFFCodes.Ellipsoid.

```
info = geotiffinfo('boston.tif');
e = referenceEllipsoid(info.GeoTIFFCodes.Ellipsoid)

e =

  referenceEllipsoid

  Properties:
                Code: 7019
                Name: 'GRS 1980'
```

```
            LengthUnit: 'meter'
        SemimajorAxis: 6378137
        SemiminorAxis: 6356752.31414036
    InverseFlattening: 298.257222101
         Eccentricity: 0.0818191910428158
```

See Also

oblateSpheroid | referenceSphere | validateLengthUnit | wgs84Ellipsoid

Purpose

Transform geodetic to geocentric (ECEF) coordinates

Syntax

```
[X,Y,Z] = geodetic2ecef(spheroid,lat,lon,h)
[X,Y,Z] = geodetic2ecef( ___ , angleUnit)
```

Description

`[X,Y,Z] = geodetic2ecef(spheroid,lat,lon,h)` returns Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian coordinates corresponding to geodetic coordinates `lat`, `lon`, `h`. Any of the three numerical arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[X,Y,Z] = geodetic2ecef( ___ , angleUnit)` adds `angleUnit` which specifies the units of inputs lat and lon.

Input Arguments

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

lat - Geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types

single | double

lon - Longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h - Ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

X - ECEF x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

Y - ECEF y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

Z - ECEF y-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D

array. Units are determined by the `LengthUnit` property of the `spheroid` object.

See Also

`referenceEllipsoid.ecef2geodetic` |
`refereceEllipsoid.ecefOffset` |

referenceEllipsoid.ecef2geodetic

Purpose

Transform geocentric (ECEF) to geodetic coordinates

Syntax

```
[lat,lon,h] = ecef2geodetic(spheroid,X,Y,Z)
[lat,lon,h] = ecef2geodetic( ___ , angleUnit)
```

Description

`[lat,lon,h] = ecef2geodetic(spheroid,X,Y,Z)` returns geodetic coordinates corresponding to coordinates `X`, `Y`, `Z` in an Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian system. Any of the three numerical arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[lat,lon,h] = ecef2geodetic( ___ , angleUnit)` adds `angleUnit` which specifies the units of outputs lat and lon.

Input Arguments

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

X - ECEF x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types

single | double

Y - ECEF y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

Z - ECEF z-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

lat - Geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the closed interval [-90 90].

lon - Longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the interval [-180 180].

h - Ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object

See Also

`referenceEllipsoid.geodetic2ecef` |
`referenceEllipsoid.ecefOffset` |

Purpose

Cartesian ECEF offset between geodetic positions

Syntax

```
[U,V,W] = ecefOffset(spheroid,lat1,lon1,h1,lat2,lon2,h2)
[U,V,W] = ecefOffset( ___ , angleUnit)
```

Description

`[U,V,W] = ecefOffset(spheroid,lat1,lon1,h1,lat2,lon2,h2)` returns the components of the 3-D offset vector from an initial geodetic position specified by`lat1`,`lon1`,`h1` to a final position specified by `lat2`,`lon2`,`h2` with respect to an Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian system. Any of the six numerical arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[U,V,W] = ecefOffset( ___ , angleUnit)` adds `angleUnit` which specifies the units of inputs lat1, lon1, lat2, and lon2.

Input Arguments

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

lat1 - Initial geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more initial positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument angleUnit, if supplied, and in degrees, otherwise.

Data Types

single | double

lon1 - Initial longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more initial positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument angleUnit, if supplied, and in degrees, otherwise.

Data Types
single | double

h1 - Initial ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more initial positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the LengthUnit property of the spheroid object.

Data Types
single | double

lat2 - Final geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more final positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument angleUnit, if supplied, and in degrees, otherwise.

Data Types
single | double

lon2 - Final longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more final positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument angleUnit, if supplied, and in degrees, otherwise.

Data Types
single | double

h2 - Final ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more final positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the LengthUnit property of the spheroid object.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

U - Offset vector x-components in ECEF system

scalar value | vector | matrix | N-D array

x-components of one or more Cartesian offset vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Values equal the difference in ECEF x-coordinates between initial and final positions. Units are determined by the LengthUnit property of the spheroid object.

V - Offset vector y-components in ECEF system

scalar value | vector | matrix | N-D array

y-components of one or more Cartesian offset vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Values equal the difference in ECEF y-coordinates between initial and final positions. Units are determined by the LengthUnit property of the spheroid object.

W - Offset vector z-components in ECEF system

scalar value | vector | matrix | N-D array

z-components of one or more Cartesian offset vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Values equal the difference in ECEF z-coordinates between initial and final positions. Units are determined by the LengthUnit property of the spheroid object.

See Also

`referenceEllipsoid.geodetic2ecef` |
`referenceEllipsoid.ecef2geodetic` |

referenceSphere

Purpose

Reference sphere

Description

A `referenceSphere` object represents a sphere with a specific name and radius that you can use in map projections and other geodetic operations.

Construction

`S = referenceSphere` returns a reference sphere object representing a unit sphere.

`S = referenceSphere(name)` returns a reference sphere object corresponding to the string, `name`, which specifies an approximately spherical body. The radius of the reference sphere is given in meters.

`S = referenceSphere(name, lengthUnit)` returns a reference sphere with radius given in the specified unit of length, `lengthUnit`.

Input Arguments

name

Name of reference sphere

One of the following values: `'unit sphere'`, `'earth'`, `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, `'pluto'`. Name is case-insensitive.

DataType: String.

lengthUnit

Unit of length for radius

lengthUnit can be any length unit string supported by `validateLengthUnit`.

Properties

Name

Name of reference sphere

A string naming or describing the reference sphere.

Default: `'Unit Sphere'`.

LengthUnit

Unit of length for radius

The empty string, or any unit of length string accepted by the `validateLengthUnit` function.

Default: `''`.

Radius

Radius of sphere

DataType: Positive, finite scalar.

Default: `1`.

SemimajorAxis

Equatorial radius of sphere `a = Radius`

The SemimajorAxis property is equal to `Radius`.

Access: Read only

SemiminorAxis

Distance from center of sphere to pole, `b = Radius`

Its value is equal to `Radius`.

Access: Read only

InverseFlattening

Reciprocal of flattening, `1/f = Inf`

The `InverseFlattening` property provides consistency with the `oblateSpheroid` class. Its value is always `Inf`.

Access: Read only

Eccentricity

First eccentricity of sphere, `ecc = 0`

The `Eccentricity` property provides consistency with the `oblateSpheroid` class. Its value is always `0`.

Access: Read only

Flattening

Flattening of sphere, `f = 0`

The `Flattening` property provides consistency with the `oblateSpheroid` class. Its value is always `0`.

Access: Read only

ThirdFlattening

Third flattening of sphere, `n = 0`

The `ThirdFlattening` property provides consistency with the `oblateSpheroid` class. Its value is always 0.

Access: Read only

MeanRadius

Mean radius of sphere

The `MeanRadius` property provides consistency with the `oblateSpheroid` class. Its value is always equal to `Radius`.

Access: Read only

SurfaceArea

Surface area of sphere

The surface area of the sphere has units consistent with the `LengthUnit` property. For example, if `LengthUnit` is `'kilometer'` then `SurfaceArea` is in `square kilometers`.

Access: Read only

Volume

Volume of sphere

The volume of the sphere has units consistent with the `LengthUnit` property. For example, if `LengthUnit` is `'kilometer'` then `Volume` is in `cubic kilometers`.

Access: Read only

Methods

ecef2geodetic	Transform geocentric (ECEF) to geodetic coordinates
ecefOffset	Cartesian ECEF offset between geodetic positions
geodetic2ecef	Transform geodetic to geocentric (ECEF) coordinates

Copy Semantics

Value. To learn how value classes affect copy operations, see Copying Objects.

Examples

Create a Model of Earth in Kilometers

Create a model of earth in kilometers using the `referenceSphere` object.

Construct a reference sphere that models the Earth as a sphere with a radius of 6371000 meters. Then switch the unit of length to kilometers.

```
s = referenceSphere('Earth')
s.LengthUnit = 'kilometer'
```

```
s =

  referenceSphere

  Properties:
          Name: 'Earth'
    LengthUnit: 'meter'
        Radius: 6371000
```

```
s =

  referenceSphere

  Properties:
          Name: 'Earth'
    LengthUnit: 'kilometer'
        Radius: 6371
```

Determine the surface area of the sphere in square kilometers.

```
s.SurfaceArea
```

```
ans =

   5.1006e+08
```

Find the volume of the sphere in cubic kilometers.

```
s.Volume
```

```
ans =

   1.0832e+12
```

See Also

`referenceEllipsoid` | `validateLengthUnit`

Purpose

Transform geodetic to geocentric (ECEF) coordinates

Syntax

```
[X,Y,Z] = geodetic2ecef(spheroid,lat,lon,h)
[X,Y,Z] = geodetic2ecef( ___ , angleUnit)
```

Description

`[X,Y,Z] = geodetic2ecef(spheroid,lat,lon,h)` returns Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian coordinates corresponding to geodetic coordinates `lat`, `lon`, `h`. Any of the three numerical arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[X,Y,Z] = geodetic2ecef( ___ , angleUnit)` adds `angleUnit` which specifies the units of inputs lat and lon.

Input Arguments

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

lat - Geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types

single | double

lon - Longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument `angleUnit`, if supplied, and in degrees, otherwise.

Data Types
single | double

h - Ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more points, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

X - ECEF x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

Y - ECEF y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object.

Z - ECEF y-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D

array. Units are determined by the `LengthUnit` property of the `spheroid` object.

See Also

`referenceSphere.ecef2geodetic` | `referenceSphere.ecefOffset` |

referenceSphere.ecef2geodetic

Purpose

Transform geocentric (ECEF) to geodetic coordinates

Syntax

```
[lat,lon,h] = ecef2geodetic(spheroid,X,Y,Z)
[lat,lon,h] = ecef2geodetic( ___ , angleUnit)
```

Description

`[lat,lon,h] = ecef2geodetic(spheroid,X,Y,Z)` returns geodetic coordinates corresponding to coordinates `X`, `Y`, `Z` in an Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian system. Any of the three numerical arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[lat,lon,h] = ecef2geodetic( ___ , angleUnit)` adds `angleUnit` which specifies the units of outputs lat and lon.

Input Arguments

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

X - ECEF x-coordinates

scalar value | vector | matrix | N-D array

x-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types

single | double

Y - ECEF y-coordinates

scalar value | vector | matrix | N-D array

y-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

Z - ECEF z-coordinates

scalar value | vector | matrix | N-D array

z-coordinates of one or more points in the spheroid-centric ECEF system, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the `LengthUnit` property of the `spheroid` object.

Data Types
single | double

angleUnit - Units of angles

`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

lat - Geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the closed interval [-90 90].

lon - Longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the input argument `angleUnit`, if supplied; values are in degrees, otherwise. When in degrees, they lie in the interval [-180 180].

h - Ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more points, returned as a scalar value, vector, matrix, or N-D array. Units are determined by the `LengthUnit` property of the `spheroid` object

See Also

`referenceSphere.geodetic2ecef` | `referenceSphere.ecefOffset` |

Purpose

Cartesian ECEF offset between geodetic positions

Syntax

```
[U,V,W] = ecefOffset(spheroid,lat1,lon1,h1,lat2,lon2,h2)
[U,V,W] = ecefOffset( ___ , angleUnit)
```

Description

`[U,V,W] = ecefOffset(spheroid,lat1,lon1,h1,lat2,lon2,h2)` returns the components of the 3-D offset vector from an initial geodetic position specified by`lat1`,`lon1`,`h1` to a final position specified by `lat2`,`lon2`,`h2` with respect to an Earth-Centered Earth-Fixed (ECEF) spheroid-centric Cartesian system. Any of the six numerical arguments can be scalar, even when the others are nonscalar; but all nonscalar numeric arguments must match in size.

`[U,V,W] = ecefOffset( ___ , angleUnit)` adds `angleUnit` which specifies the units of inputs lat1, lon1, lat2, and lon2.

Input Arguments

spheroid - Reference spheroid

scalar referenceEllipsoid | oblateSpheroid | referenceSphere object

Reference spheroid, specified as a scalar referenceEllipsoid, oblateSpheroid, or referenceSphere object.

lat1 - Initial geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more initial positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument angleUnit, if supplied, and in degrees, otherwise.

Data Types

single | double

lon1 - Initial longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more initial positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument angleUnit, if supplied, and in degrees, otherwise.

Data Types
single | double

h1 - Initial ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more initial positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the LengthUnit property of the spheroid object.

Data Types
single | double

lat2 - Final geodetic latitudes

scalar value | vector | matrix | N-D array

Geodetic latitudes of one or more final positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument angleUnit, if supplied, and in degrees, otherwise.

Data Types
single | double

lon2 - Final longitudes

scalar value | vector | matrix | N-D array

Longitudes of one or more final positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the input argument angleUnit, if supplied, and in degrees, otherwise.

Data Types
single | double

h2 - Final ellipsoidal heights

scalar value | vector | matrix | N-D array

Ellipsoidal heights of one or more final positions, specified as a scalar value, vector, matrix, or N-D array. Values must be in units that match the LengthUnit property of the spheroid object.

Data Types
single | double

angleUnit - Units of angles
`'degrees'` (default) | `'radians'`

Units of angles, specified as 'degrees' (default), or 'radians'.

Data Types
char

Output Arguments

U - Offset vector x-components in ECEF system
scalar value | vector | matrix | N-D array

x-components of one or more Cartesian offset vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Values equal the difference in ECEF x-coordinates between initial and final positions. Units are determined by the LengthUnit property of the spheroid object.

V - Offset vector y-components in ECEF system
scalar value | vector | matrix | N-D array

y-components of one or more Cartesian offset vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Values equal the difference in ECEF y-coordinates between initial and final positions. Units are determined by the LengthUnit property of the spheroid object.

W - Offset vector z-components in ECEF system
scalar value | vector | matrix | N-D array

z-components of one or more Cartesian offset vectors in the spheroid-centric ECEF system, returned as a scalar value, vector, matrix, or N-D array. Values equal the difference in ECEF z-coordinates between initial and final positions. Units are determined by the LengthUnit property of the spheroid object.

See Also

`referenceSphere.geodetic2ecef` | `referenceSphere.ecef2geodetic` |

refmat2vec

Purpose

Convert referencing matrix to referencing vector

Syntax

```
refvec = refmat2vec(R,s)
```

Description

`refvec = refmat2vec(R,s)` converts a referencing matrix, `R`, to the three-element referencing vector `refvec`. `R` is a 3-by-2 referencing matrix defining a two-dimensional affine transformation from pixel coordinates to spatial coordinates. `s` is the size of the array (data grid) that is being referenced. `refvec` is a 1-by-3 referencing vector having elements `[cells/degree north-latitude west-longitude]` with latitude and longitude limits specified in degrees.

Examples

```
% Verify the conversion of the geoid referencing vector to a
% referencing matrix.
load geoid;
R = refvec2mat(geoidlegend, size(geoid));
V = refmat2vec(R, size(geoid));
```

See Also

`makerefmat` | `refvec2mat`

Purpose

Convert referencing vector to referencing matrix

Syntax

```
R = refvec2mat(refvec,s)
```

Description

`R = refvec2mat(refvec,s)` converts a referencing vector, `refvec`, to the referencing matrix `R`. `refvec` is a 1-by-3 referencing vector having elements `[cells/degree north-latitude west-longitude]` with latitude and longitude limits specified in degrees. `s` is the size of the array (data grid) that is being referenced. `R` is a 3-by-2 referencing matrix defining a two-dimensional affine transformation from pixel coordinates to spatial coordinates.

Examples

```
% Convert the geoid referencing vector to a referencing matrix
 load geoid;
R = refvec2mat(geoidlegend, size(geoid));
```

See Also

`makerefmat` | `refmat2vec`

refmatToGeoRasterReference

Purpose

Referencing matrix to GeoRasterReference object

Syntax

```
R = refmatToGeoRasterReference(refmat, rasterSize)
R = refmatToGeoRasterReference(refmat,
rasterSize, func_name,
   var_name, arg_pos)
R = refmatToGeoRasterReference(Rin, rasterSize, ...)
```

Description

`R = refmatToGeoRasterReference(refmat, rasterSize)` constructs a `spatialref.GeoRasterReference` object, `R`, from a referencing matrix, `refmat`, and a size vector, `rasterSize`.

`R = refmatToGeoRasterReference(refmat, rasterSize, func_name, var_name, arg_pos)` uses up to three optional arguments to provide additional information. This information is used to construct error messages if either the `refmat` or `rasterSize` inputs turn out to be invalid. Thus, you can use `refmatToGeoRasterReference` for both validating and converting a referencing matrix. The optional inputs work just like their counterparts in the MATLAB function `validateattributes`.

`R = refmatToGeoRasterReference(Rin, rasterSize, ...)`, where `Rin` is a `spatialref.GeoRasterReference` object, verifies that `Rin.RasterSize` is consistent with `rasterSize`, then copies `Rin` to `R`.

Input Arguments

refmat

Any valid referencing matrix subject to the two following constraints. First, the matrix must lead to valid latitude and longitude limits when combined with `rasterSize`. Second, the matrix columns and rows must be aligned with meridians and parallels, respectively.

rasterSize

Size vector `[M N ...]` specifying the number of rows (`M`) and columns (`N`) in the raster or image to be associated with the `GeoRasterReference` object, `R`. For convenience, `rasterSize` may be a row vector with more

than two elements. This flexibility allows you to specify the size in the following way:

```
R = refmatToGeoRasterReference(refmat, size(RGB))
```

where `RGB` is *M*-by-*N*-by-3. However, in such cases, only the first two elements of the size vector are actually used. The higher (non-spatial) dimensions are ignored.

func_name

String that specifies the name used in the formatted error message to identify the function checking the input.

var_name

String that specifies the name used in the formatted error message to identify the referencing matrix.

arg_pos

Positive integer that indicates the position of the referencing matrix checked in the function argument list. `refmatToGeoRasterReference` includes this information in the formatted error message.

Rin

`spatialref.GeoRasterReference` object.

Output Arguments

R

`spatialref.GeoRasterReference` object, `R`.

Examples

Convert a referencing matrix to a `spatialref.GeoRasterReference` object:

```
% Construct a referencing matrix for a regular grid that covers the
% entire globe with 1-degree cells.
rasterSize = [180 360];
refmat = makerefmat( ...
```

```
   'RasterSize', rasterSize, 'Latlim', [-90 90], ...
   'Lonlim', [0 360])

% Convert to a spatialref.GeoRasterReference object.
R = refmatToGeoRasterReference(refmat, rasterSize)

% For comparison, construct a referencing object directly.
georasterref( ...
   'RasterSize', rasterSize, 'Latlim', [-90 90], 'Lonlim', [0 360])
```

See Also

georasterref | refvecToGeoRasterReference

Purpose

Referencing matrix to `MapRasterReference` object

Syntax

```
R = refmatToMapRasterReference(refmat, rasterSize)
R = refmatToMapRasterReference(refmat,
rasterSize, func_name,
   var_name, arg_pos)
R = refmatToMapRasterReference(Rin, rasterSize, ...)
```

Description

`R = refmatToMapRasterReference(refmat, rasterSize)` constructs a `spatialref.MapRasterReference` object, `R`, from a referencing matrix, `remat`, and size vector, `rasterSize`.

`R = refmatToMapRasterReference(refmat, rasterSize, func_name, var_name, arg_pos)` uses up to three optional arguments to provide additional information. This information is used to construct error messages if either the `refmat` or `rasterSize` inputs turn out to be invalid. Thus, you can use `refmatToMapRasterReference` for both validating and converting a referencing matrix. The optional inputs work just `like` their counterparts in the MATLAB function `validateattributes`.

`R = refmatToMapRasterReference(Rin, rasterSize, ...)` verifies that `Rin.RasterSize` is consistent with `rasterSize`, then copies `Rin` to `R`.

Input Arguments

refmat

Referencing matrix

rasterSize

Size vector `[M N ...]` specifying the number of rows (*M*) and columns (*N*) in the raster or image to be associated with the `MapRasterReference` object, `R`. For convenience, `rasterSize` may be a row vector with more than two elements. This flexibility allows you to specify the size in the following way:

```
R = refmatToMapRasterReference(refmat, size(RGB))
```

where `RGB` is *M*-by-*N*-by-3. However, in such cases, only the first two elements of the size vector are actually used. The higher (non-spatial) dimensions are ignored.

func_name

String that specifies the name used in the formatted error message to identify the function checking the input.

var_name

String that specifies the name used in the formatted error message to identify the referencing matrix.

arg_pos

Positive integer that indicates the position of the referencing matrix checked in the function argument list. `refmatToMapRasterReference` includes this information in the formatted error message.

R_in

`spatialref.MapRasterReference` object

Output Arguments

R

`spatialref.MapRasterReference` object

Examples

Try converting a referencing matrix manually versus using the `maprasterref` function.

```
% Import a referencing matrix from a world file for a
% 2000-by-2000 orthoimage referenced to the Massachusetts
% State Plane Mainland coordinate system.
refmat = worldfileread('concord_ortho_e.tfw')

% Import the corresponding TIFF image and use its size to
% help convert the referencing matrix to a referencing object.
[X, cmap] = imread('concord_ortho_e.tif');
```

```
R = refmatToMapRasterReference(refmat, size(X))

% Use the mapbbox function to obtain the map limits independently
% of the referencing object.
bbox = mapbbox(refmat, size(X))
xLimWorld = bbox(:,1)';  % Transpose the first column
yLimWorld = bbox(:,2)';  % Transpose the second column

% Construct a referencing object directly, for comparison.
maprasterref('RasterSize', size(X), 'ColumnsStartFrom', 'north', ...
  'XLimWorld', xLimWorld, 'YLimWorld', yLimWorld)
```

See Also

maprasterref | refmatToGeoRasterReference

refmatToWorldFileMatrix

Purpose

Convert referencing matrix to world file matrix

Syntax

```
W = refmatToWorldFileMatrix(refmat)
```

Description

`W = refmatToWorldFileMatrix(refmat)` converts the 3-by-2 referencing matrix `refmat` to a 2-by-3 world file matrix `W`.

Definitions

Referencing Matrix

See `makerefmat`.

World File Matrix for Planar System

See `spatialref.MapRasterReference.worldFileMatrix`.

World File Matrix for Geographic System

See `spatialref.GeoRasterReference.worldFileMatrix`.

See Also

`worldFileMatrixToRefmat`

Purpose

Referencing vector to `GeoRasterReference` object

Syntax

```
R = refvecToGeoRasterReference(refvec, rasterSize)
R = refvecToGeoRasterReference(refvec,
rasterSize, func_name,
   var_name, arg_pos)
R = refvecToGeoRasterReference(Rin, rasterSize, ...)
```

Description

`R = refvecToGeoRasterReference(refvec, rasterSize)` constructs a `spatialref.GeoRasterReference` object, `R`, from a referencing vector, `refvec`, and a size vector, `rasterSize`.

`R = refvecToGeoRasterReference(refvec, rasterSize, func_name, var_name, arg_pos)` uses up to three optional arguments to provide additional information. This information is used to construct error messages if either the `refvec` or `rasterSize` inputs turn out to be invalid. Thus, you can use `refvecToGeoRasterReference` for both validating and converting a referencing vector. The optional inputs work just like their counterparts in the MATLAB function `validateattributes`.

`R = refvecToGeoRasterReference(Rin, rasterSize, ...)` verifies that `Rin.RasterSize` is consistent with `rasterSize`, then copies `Rin` to `R`.

Input Arguments

refvec

Any valid 1-by-3 referencing vector, as long as the cell size `1/refvec(1)`, northwest corner latitude `refvec(2)`, and northwest corner longitude `refvec(3)` lead to valid latitude and longitude limits when combined with the `rasterSize` vector.

rasterSize

Size vector `[M N ...]` specifying the number of rows (`M`) and columns (`N`) in the raster or image to be associated with the `GeoRasterReference` object, `R`.

func_name

String that specifies the name used in the formatted error message to identify the function checking the input.

var_name

String that specifies the name used in the formatted error message to identify the referencing vector.

arg_pos

Positive integer that indicates the position of the referencing vector checked in the function argument list. `refvecToGeoRasterReference` includes this information in the formatted error message.

Rin

`spatialref.GeoRasterReference` object.

Output Arguments

R

`spatialref.GeoRasterReference` object, `R`.

Examples

Try converting a referencing vector manually versus using the `georasterref` function.

```
% Construct a referencing vector for a regular 180-by-240 grid
% covering an area that includes the Korean Peninsula, with 12 cells
% per degree.
refvec = [12  45  115];

% Convert to a spatialref.GeoRasterReference object:
rasterSize = [180 240];
R = refvecToGeoRasterReference(refvec, rasterSize)

% For comparison, construct a referencing object directly:
[latlim, lonlim] = limitm(zeros(rasterSize), refvec);
georasterref('RasterSize', rasterSize, 'Latlim', latlim, ...
```

```
    'Lonlim', lonlim)
```

See Also

georasterref | refmatToGeoRasterReference

removeExtraNanSeparators

Purpose

Clean up NaN separators in polygons and lines

Syntax

```
[xdata, ydata] = removeExtraNanSeparators(xdata,ydata)
[xdata, ydata, zdata] = removeExtraNanSeparators(xdata,ydata,
   zdata)
```

Description

`[xdata, ydata] = removeExtraNanSeparators(xdata,ydata)` removes NaNs from the vectors `xdata` and `ydata`, leaving only isolated `NaN` separators. If present, one or more leading `NaN`s are removed entirely. If present, a single trailing `NaN` is preserved. `NaN`s are removed, but never added, so if the input lacks a trailing `NaN`, so will the output. `xdata` and `ydata` must match in size and have identical `NaN` locations.

`[xdata, ydata, zdata] = removeExtraNanSeparators(xdata,ydata,zdata)` removes `NaN`s from the vectors `xdata`, `ydata`, and `zdata`, leaving only isolated `NaN` separators and optionally, if consistent with the input, a single trailing `NaN`.

Examples

```
xin = [NaN NaN 1:3 NaN 4:5 NaN NaN NaN 6:9 NaN NaN];
yin = xin;
[xout, yout] = removeExtraNanSeparators(xin, yin);
xout

xout =
  1  2  3  NaN  4  5 NaN  6  7  8  9  NaN

xin = [NaN 1:3 NaN NaN 4:5 NaN NaN NaN 6:9]'
yin = xin;
zin = xin;
[xout, yout, zout] = removeExtraNanSeparators(xin, yin, zin);
xout

xout =
     1
     2
     3
```

```
   NaN
     4
     5
   NaN
     6
     7
     8
     9
```

resizem

Purpose

Resize regular data grid

Syntax

```
Z = resizem(Z1,scale)
Z = resizem(Z1,[numrows numcols])
[Z,R] = resizem(Z1,scale,R1)
[Z,R] = resizem(Z1,[numrows numcols],R1)
[...] = resizem(..., method)
```

Description

`Z = resizem(Z1,scale)` returns a regular data grid `Z` that is `scale` times the size of the input, `Z1`. `resizem` uses interpolation to resample to a new sample density/cell size. If `scale` is between 0 and 1, the size of `Z` is smaller than the size of `Z1`. If `scale` is greater than 1, the size of `Z` is larger. For example, if `scale` is 0.5, the number of rows and the number of columns will be halved. By default, `resizem` uses nearest neighbor interpolation.

`Z = resizem(Z1,[numrows numcols])` resizes `Z1` to have `numrows` rows and `numcols` columns. `numrows` and `numcols` must be positive whole numbers.

`[Z,R] = resizem(Z1,scale,R1)` or `[Z,R] = resizem(Z1,[numrows numcols],R1)` resizes a regular data grid that is spatially referenced by `R1`. `R1` can be a referencing vector, a referencing matrix, or a `spatialref.GeoRasterReference` object.

If `R1` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z1)` and its `RasterInterpretation` must be `'cells'`.

If `R1` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R1` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R1
```

If R1 is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. The output R will be the same type as R1 (referencing object, vector, or matrix). If R1 is a referencing vector, the form [numrows numcols] is not supported and scale must be a scalar resizing factor.

[...] = resizem(..., method) resizes a regular data grid using one of the following three interpolation methods:

Method	Description
'nearest'	nearest neighbor interpolation (default)
'bilinear'	bilinear interpolation
'bicubic'	bicubic interpolation

If the grid size is being reduced (scale is less than 1 or [numrows numcols] is less than the size of the input grid) and method is 'bilinear' or 'bicubic', resizem applies a low-pass filter before interpolation, to reduce aliasing. The default filter size is 11-by-11. You can specify a different length for the default filter using:

```
[...] = resizem(..., method, n)
```

n is an integer scalar specifying the size of the filter, which is n-by-n. If n is 0 or method is 'nearest', resizem omits the filtering step. You can also specify your own filter h using:

```
[...] = resizem(..., method, h)
```

h is any two-dimensional FIR filter (such as those returned by Image Processing Toolbox functions ftrans2, fwind1, fwind2, or fsamp2). If H is specified, filtering is applied even when method is 'nearest'.

Examples

Double the size of a grid then reduce it using different methods:

```
Z = [1 2; 3 4]
```

```
Z =
      1  2
      3  4

neargrid = resizem(Z,2)

neargrid =
      1  1  2  2
      1  1  2  2
      3  3  4  4
      3  3  4  4

bilingrid = resizem(Z,2,'bilinear')

bilingrid =
    1.0000    1.3333    1.6667    2.0000
    1.6667    2.0000    2.3333    2.6667
    2.3333    2.6667    3.0000    3.3333
    3.0000    3.3333    3.6667    4.0000

bicubgrid = resizem(bilingrid,[3 2],'bicubic')

bicubgrid =
    0.7406    1.2994
    1.6616    2.3462
    1.9718    2.5306
```

See Also

filter2

Purpose

Restack objects within map axes

Syntax

```
restack(h,position)
```

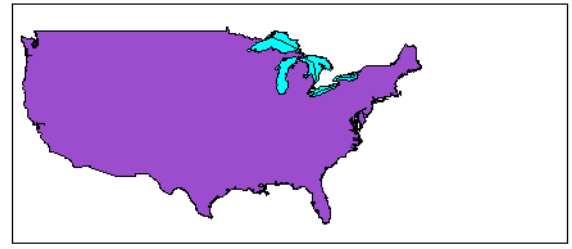
Description

`restack(h,position)` changes the stacking position of the object `h` within the axes. `h` can be a handle, a vector of handles to graphics objects, or a name string recognized by `handlem`. Recognized *`position`* strings are `'top'`, `'bottom'`, `'bot'`, `'up'`, or `'down'`.

Examples

Restack the great lakes to lie on top of `conus`:

```
figure; axesm miller
load conus
h = geoshow(gtlakelat, gtlakelon,...
    'DisplayType', 'polygon', 'FaceColor', 'cyan');
geoshow(uslat, uslon,...
    'DisplayType', 'polygon', 'FaceColor', [0.6 0.3 0.8])
% The great lakes were plotted first but need to be on top
% Cast handle to great lakes object to double in call to RESTACK
restack(double(h),'top')
```



Tips

This function is the command line equivalent of the stacking buttons in the `mobjects` graphical user interface. The stacking order is the order of the children of the axes.

See Also

`mobjects`

rhxrh

Purpose

Intersection points for pairs of rhumb lines

Syntax

```
[newlat,newlong] = rhxrh(lat1,lon1,az1,lat2,lon2,az2)
[newlat,newlon] = rhxrh(lat1,lon1,az1,lat2,lon2,az2,units)
```

Description

`[newlat,newlong] = rhxrh(lat1,lon1,az1,lat2,lon2,az2)` returns in `newlat` and `newlon` the location of the intersection point for each pair of rhumb lines input in *rhumb line notation*. For example, the first line in the pair passes through the point (`lat1`,`lon1`) and has a constant azimuth of `az1`. When the two rhumb lines are identical or do not intersect (conditions that are not, in general, apparent by inspection), two `NaN`s are returned instead and a warning is displayed. The inputs must be column vectors.

`[newlat,newlon] = rhxrh(lat1,lon1,az1,lat2,lon2,az2,units)` specifies the units used, where *`units`* is any valid units string. The default units are `'degrees'`.

For any pair of rhumb lines, there are three possible intersection conditions: the lines are identical, they intersect once, or they do not intersect at all (except at the poles, where all nonequatorial rhumb lines meet—this is not considered an intersection). `rhxrh` does not allow multiple rhumb line intersections, although it is possible to construct cases in which such a condition occurs. See the following discussion of Limitations.

Rhumb line notation consists of a point on the line and the constant azimuth of the line.

Examples

Given a starting point at (10ºN,56ºW), a plane maintains a constant heading of 35º. Another plane starts at (0º,10ºW) and proceeds at a constant heading of 310º (–50º). Where would their two paths cross each other?

```
[newlat,newlong] = rhxrh(10,-56,35,0,-10,310)

newlat =
   26.9774
```

```
newlong =
  -43.4088
```

Limitations

Rhumb lines are specifically helpful in navigation because they represent lines of constant heading, whereas great circles have, in general, continuously changing heading. In fact, the Mercator projection was originally designed so that rhumb lines plot as straight lines, which facilitates both manual plotting with a straightedge and numerical calculations using a Cartesian planar representation. When a rhumb line proceeds off the left or right *edge* of this representation at some latitude, it reappears on the other edge at the same latitude and continues on the same slope. For rhumb lines where this occurs—for example, one with a heading of 85º—it is easy to imagine another rhumb line, say one with a heading of 0º, repeatedly intersecting the first. The real-world uses of rhumb lines make this merely an intellectual exercise, however, for in practice it is always clear which *crossing* line segment is relevant. The function `rhxrh` returns at most one intersection, selecting in each case that line segment containing the input starting point for its computation.

See Also

`gcxgc` | `gcxsc` | `scxsc` | `crossfix` | `polyxpoly` | `navfix`

rootlayr

Purpose

Construct cell array of workspace variables for `mlayers` tool

Syntax

```
rootlayr
```

Description

`rootlayr` allows the `mlayers` tool to be used with workspace variables. It constructs a cell array that contains all the structure variables in the current workspace. This cell array is returned in the variable `ans`, which can then be an input to `mlayers`. If there is an existing variable named `ans`, it is overwritten.

The recommended calling procedure is `rootlayr;mlayers(ans);`

Examples

`rootlayr` creates a cell array named `ans`, consisting of the three structure variables in the following workspace.

```
whos
  Name          Size         Bytes  Class
  borders       1x1          38390  struct array
  lats       2345x1          18760  double array
  lons       2345x1          18760  double array
  nation        1x1          70224  struct array
  states        1x51        254970  struct array

rootlayr
ans
  ans =
    [1x1  struct]    'borders'
    [1x1  struct]    'nation'
    [1x51 struct]    'states'
```

The function `mlayers(ans)` can now be used to activate the `mlayers` tool for the structures contained in `ans`.

See Also

`mlayers`

Purpose

Transform vector map data to new origin and orientation

Syntax

```
[lat1,lon1] = rotatem(lat,lon,origin,'forward')
[lat1,lon1] = rotatem(lat,lon,origin,'inverse')
[lat1,lon1] = rotatem(lat,lon,origin,'forward',units)
[lat1,lon1] = rotatem(lat,lon,origin,'forward',units)
```

Description

`[lat1,lon1] = rotatem(lat,lon,origin,'forward')` transforms latitude and longitude data (`lat` and `lon`) to their new coordinates (`lat1` and `lon1`) in a coordinate system resulting from Euler angle rotations as specified by `origin`. The input `origin` is a three- (or two-) element vector having the form `[latitude longitude orientation]`. The latitude and longitude are the coordinates of the point in the original system, which is the center of the output system. The orientation is the azimuth from the new origin point to the original North Pole in the new system. If `origin` has only two elements, the orientation is assumed to be 0º. This `origin` vector might be the output of `putpole` or `newpole`.

`[lat1,lon1] = rotatem(lat,lon,origin,'inverse')` transforms latitude and longitude data (`lat` and `lon`) in a coordinate system *that has been transformed* by Euler angle rotations specified by `origin` to their coordinates (`lat1` and `lon1`) in the coordinate system *from which they were originally transformed*. In a sense, this *undoes* the `'forward'` process. Be warned, however, that if data is rotated forward and then inverted, the final data might not be identical to the original. This is because of roundoff and *data collapse* at the original and intermediate singularities (the poles).

`[lat1,lon1] = rotatem(lat,lon,origin,'forward',units)` and `[lat1,lon1] = rotatem(lat,lon,origin,'forward',units)` specify the angle units of the data, where *`units`* is any recognized angle units string. The default is `'radians'`. Note that this default is different from that of most functions.

The `rotatem` function transforms vector map data to a new coordinate system.

An analytical use of the new data can be realized in conjunction with the `newpole` function. If a selected point is made the *north pole* of

the new system, then when new vector data is created with `rotatem`, the distance of every data point from this new north pole is its new colatitude (90º minus latitude). The absolute difference in the great circle azimuths between every pair of points from their new *pole* is the same as the difference in their new longitudes.

Examples

What are the coordinates of Rio de Janeiro (23ºS,43ºW) in a coordinate system in which New York (41ºN,74ºW) is made the North Pole? Use the `newpole` function to get the origin vector associated with putting New York at the pole:

```
nylat = 41; nylon = -74;
riolat = -23; riolon = -43;
origin = newpole(nylat,nylon);
[riolat1,riolon1] = rotatem(riolat,riolon,origin,...
                            'forward','degrees')

riolat1 =
   19.8247
riolon1 =
 -149.7375
```

What does this mean? For one thing, the colatitude of Rio in this new system is its distance from New York. Compare the distance between the original points and the new colatitude:

```
dist = distance(nylat,nylon,riolat,riolon)

dist =
   70.1753

90-riolat1

ans =
   70.1753
```

See Also

`neworig` | `newpole` | `org2pol` | `putpole`

Purpose

Rotate text to projected graticule

Syntax

```
rotatetext
rotatetext(objects)
rotatetext(objects,'inverse')
```

Description

`rotatetext` rotates displayed text objects to account for the curvature of the graticule. The objects are selected interactively from a graphical user interface.

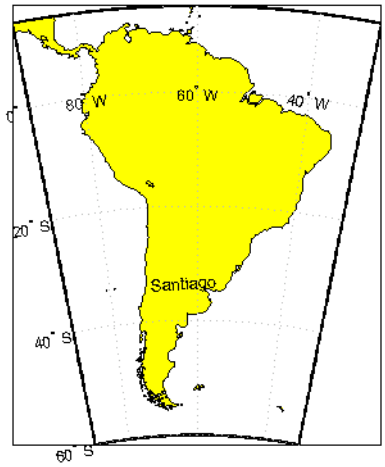
`rotatetext(objects)` rotates the selected objects. `objects` can be a name string recognized by `handlem` or a vector of handles to displayed text objects.

`rotatetext(objects,'inverse')` removes the rotation added by an earlier use of `rotatetext`. If omitted, `'forward'` is assumed.

Examples

Add text to a map and rotate the text to the graticule.

```
figure
worldmap('south america')
geoshow('landareas.shp','facecolor','yellow')
cities = shaperead('worldcities.shp', 'UseGeoCoords', true);
Santiago = strcmp('Santiago',{cities(:).Name});
h=textm(cities(Santiago).Lat, cities(Santiago).Lon, ...
     'Santiago');
rotatetext(h)
```



Tips

You can rotate meridian and parallel labels automatically by setting the map axes `LabelRotation` property to `'on'`.

See Also

`vfwdtran` | `vinvtran`

Purpose

Round to multiple of 10^n

Syntax

```
roundn(x,n)
```

Description

`roundn(x,n)` rounds each element of `x` to the nearest multiple of 10^n. The variable `n` must be scalar, and integer-valued. For complex `x`, the imaginary and real parts are rounded independently. For `n = 0`, `roundn` gives the same result as `round`. That is, `roundn(x,0) == round(x)`.

Examples

Round pi to the nearest hundredth:

```
roundn(pi, -2)

ans =

    3.1400
```

Round the equatorial radius of the Earth, 6378137 meters, to the nearest kilometer:

```
roundn(6378137, 3)

ans =

     6378000
```

See Also

`round`

rsphere

Purpose

Radii of auxiliary spheres

Syntax

```
r = rsphere('biaxial',ellipsoid)
r = rsphere('biaxial',ellipsoid,method)
r = rsphere('triaxial',ellipsoid)
r = rsphere('triaxial',ellipsoid,method)
r = rsphere('eqavol',ellipsoid)
r = rsphere('authalic',ellipsoid)
r = rsphere('rectifying',ellipsoid)
r = rsphere('curve',ellipsoid,lat)
r = rsphere('curve',ellipsoid,lat,method)
r = rsphere('euler',lat1,lon1,lat2,lon2,ellipsoid)
r = rsphere('curve', ..., angleUnits)
r = rsphere(`euler', ..., angleUnits)
```

Description

`r = rsphere('biaxial',ellipsoid)` computes the arithmetic mean i.e., `(a+b)/2` where `a` and `b` are the semimajor and semiminor axes of the specified ellipsoid. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`.

`r = rsphere('biaxial',ellipsoid,`*`method`*`)` computes the arithmetic mean if the string *`method`* is `'mean'` and the geometric mean, `sqrt(a*b)`, if *`method`* is `'norm'`.

`r = rsphere('triaxial',ellipsoid)` computes the triaxial arithmetic mean of the semimajor axes, `a`, and semininor axes, `b` of the ellipsoid, `(2*a+b)/3`.

`r = rsphere('triaxial',ellipsoid,`*`method`*`)` computes the arithmetic mean if the string *`method`* is `'mean'` and the triaxial geometric mean, `(a^2*b)^(1/3)`, if *`method`* is `` `norm' ``.

`r = rsphere('eqavol',ellipsoid)` returns the radius of a sphere with a volume equal to that of the ellipsoid.

`r = rsphere('authalic',ellipsoid)` returns the radius of a sphere with a surface area equal to that of the ellipsoid.

`r = rsphere('rectifying',ellipsoid)` returns the radius of a sphere with meridional distances equal to those of the ellipsoid.

`r = rsphere('curve',ellipsoid,lat)` computes the arithmetic mean of the transverse and meridional radii of curvature at the latitude, `lat`. `lat` is in degrees.

`r = rsphere('curve',ellipsoid,lat,`*`method`*`)` computes an arithmetic mean if the string *`'method'`* is `` `mean' `` and a geometric mean if *`'method'`* is `` `norm' ``.

`r = rsphere('euler',lat1,lon1,lat2,lon2,ellipsoid)` computes the Euler radius of curvature at the midpoint of the geodesic arc defined by the endpoints `(lat1,lon1)` and `(lat2,lon2)`. `lat1, lon1,lat2,` and `lon2` are in degrees.

`r = rsphere('curve', ..., angleUns)` and `r = rsphere(`` `euler', ..., angleUns)` use the *`angleUnits`* string to specify the units of the `latitude` and `longitude` inputs. *`angleUnits`* can be `` `degrees' `` or `` `radians' ``.

Examples

Different criteria result in different spheres:

```
r = rsphere('biaxial',referenceEllipsoid('earth','km'))

r =
   6.3674e+03

r = rsphere('triaxial',referenceEllipsoid('earth','km'))

r =
   6.3710e+03

r = rsphere('curve',referenceEllipsoid('earth','km'))

r =
   6.3781e+03
```

See Also

`rcurve`

satbath

Purpose

Read 2-minute terrain/bathymetry from Smith and Sandwell

Syntax

```
[latgrat,longrat,z] = satbath
[latgrat,longrat,z] = satbath(scalefactor)
[latgrat,longrat,z] = satbath(scalefactor,latlim,lonlim)
[latgrat,longrat,z] = satbath(scalefactor,latlim,lonlim,
   gsize)
```

Description

`[latgrat,longrat,z] = satbath` reads the global topography file for the entire world (`topo_8.2.img`), returning every 50^{th} point. The result is returned as a geolocated data grid. If you use a different version of the global topography file, you need to rename it to "`topo_8.2.img`". If the file is not found on the MATLAB path, a dialog opens to request the file.

`[latgrat,longrat,z] = satbath(scalefactor)` returns the data for the entire world, subsampled by the integer `scalefactor`. A `scalefactor` of 10 returns every 10th point. The matrix at full resolution has 6336 by 10800 points.

`[latgrat,longrat,z] = satbath(scalefactor,latlim,lonlim)` returns data for the specified region. The returned data extends slightly beyond the requested area. If omitted, the entire area covered by the data file is returned. The limits are two-element vectors in units of degrees, with `latlim` in the range `[-90 90]` and `lonlim` in the range `[-180 180]`.

`[latgrat,longrat,z] = satbath(scalefactor,latlim,lonlim,gsize)` controls the size of the graticule matrices. `gsize` is a two-element vector containing the number of rows and columns desired. If omitted, a graticule the size of the data grid is returned.

Background

This is a global bathymetric model derived from ship soundings and satellite altimetry by W.H.F. Smith and D.T. Sandwell. The model was developed by iteratively adjusting gravity anomaly data from Geosat and ERS-1 against historical track line soundings. This technique takes advantage of the fact that gravity mirrors the large variations in the ocean floor as small variations in the height of the ocean's

surface. The computational procedure uses the ship track line data to calibrate the scaling between the observed surface undulations and the inferred bathymetry. Land elevations are reduced-resolution versions of GTOPO30 data.

Tips

Land elevations are given in meters above mean sea level. The data is stored in a Mercator projection grid. As a result, spatial resolution varies with latitude. The grid spacing is 2 minutes (about 4 kilometers) at the equator.

This data is available over the Internet, but subject to copyright. The data file is binary, and should be transferred with no line-ending conversion or byte swapping. This function carries out any byte swapping that might be required. The data requires about 133 MB uncompressed.

The data and documentation are available over the Internet via http and anonymous ftp. Download the latest version of file `topo_x.2.img`, where `x` is the version number, and rename it `topo_8.w.img` for compatibility with the `satbath` function.

`satbath` returns a geolocated data grid rather than a regular data grid and a referencing vector or matrix. This is because the data is in a Mercator projection, with columns evenly spaced in longitude, but with decreasing spacing for rows at higher latitudes. Referencing vectors and matrices assume that the number of cells per degrees of latitude and longitude are both constant across a data grid.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: http://www.mathworks.com/help/map/finding-geospatial-data.html .

Examples

Read the data for the Falklands Islands (Islas Malvinas) at full resolution.

```
[latgrat,longrat,mat] = satbath(1,[-55 -50],[-65 -55]);
```

```
whos

  Name          Size          Bytes  Class

  latgrat     247x301        594776  double array
  longrat     247x301        594776  double array
  mat         247x301        594776  double array
```

See Also

tbase | gtopo30 | egm96geoid

Purpose

Add or modify graphic scale on map axes

Syntax

```
scaleruler
scaleruler on
scaleruler off
scaleruler(property,value,...)
h = scaleruler(...)
```

Description

`scaleruler` toggles the display of a graphic scale. If no graphic scale is currently displayed in the current map axes, one is added. If any graphic scales are currently displayed, they are removed.

`scaleruler on` adds a graphic scale to the current map axes. Multiple graphic scales can be added to the same map axes.

`scaleruler off` removes any currently displayed graphic scales.

`scaleruler(property,value,...)` adds a graphic scale and sets the properties to the values specified. You can display a list of graphic scale properties using the command `setm(h)`, where `h` is the handle to a graphic scale object. The current values for a displayed graphic scale object can be retrieved using `getm`. The properties of a displayed graphic scale object can be modified using `setm`.

`h = scaleruler(...)` returns the `hggroup` handle to the graphic scale object.

Background

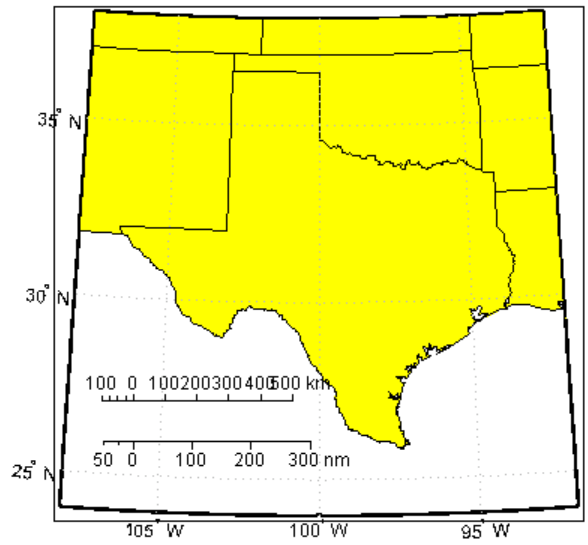
Cartographers often add graphic elements to the map to indicate its scale. Perhaps the most commonly used is the graphic scale, a ruler-like object that shows distances on the ground at the correct size for the projection.

Examples

Create a map, add a graphic scale with the default settings, and shift it up a bit. Add a second scale showing nautical miles, and change the tick marks and direction.

```
figure
usamap('Texas')
```

```
geoshow('usastatelo.shp', 'FaceColor', [0.9 0.9 0])
scaleruler on
setm(handlem('scaleruler1'), ...
    'XLoc',-6.2e5,'YLoc',3.1e6,...
    'MajorTick',0:200:600)
scaleruler('units','nm')
setm(handlem('scaleruler2'), ...
    'YLoc', 3.0e6, ...
    'MajorTick', 0:100:300,...
    'MinorTick', 0:25:50, ...
    'TickDir', 'down', ...
    'MajorTickLength', km2nm(25),...
    'MinorTickLength', km2nm(12.5))
```



Tips

You can reposition graphic scale objects by dragging them with the mouse. You can also change their positions by modifying the `XLoc` and `YLoc` properties using `setm`.

Modifying the properties of the graphic scale results in the replacement of the original object (dragging a scaleruler, however, does not replace it). For this reason, handles to the graphic scale object will change. Use `handlem('scaleruler')` to get a list of the current handles to all graphic scale objects. Use `handlem('scalerulerN')`, where `N` is an integer, to get the handle to a particular graphic scale. Use `namem` to see the names of existing graphic scale objects. The name of a graphic scale object is also stored in the read-only `'Children'` property, which is accessed using `getm`.

Use `scaleruler off`, `clmo scaleruler`, or `clmo scalerulerN` to remove the scale rulers. You can also remove a graphic scale object with `delete(h)`, or `delete(handlem(`scalerulerN'))`, where `N` is the corresponding integer.

Object Properties

Properties That Control Appearance

`Color`

`ColorSpec {no default}`

Color of the displayed graphic scale — Controls the color of the graphic scale lines and text. You can specify a color using a vector of RGB values or one of the MATLAB predefined names. By default, the graphic scale is displayed in black (`[0 0 0]`).

`FontAngle`

`{normal} | italic | oblique`

Angle of the graphic scale label text — Controls the appearance of the graphic scale text components. Use any MATLAB font angle string.

`FontName`

`courier | {helvetica} | symbol | times`

Font family name for all graphic scale labels — Sets the font for all displayed graphic scale labels. To display and print properly `FontName` must be a font that your system supports.

`FontSize`
`scalar in units specified in FontUnits {9}`

Font size — Specifies the font size to use for all displayed graphic scale labels, in units specified by the `FontUnits` property. The default point size is 9.

`FontUnits`
`inches | centimeters | normalized | {points} | pixels`

Units used to interpret the FontSize property — When set to normalized, the toolbox interprets the value of `FontSize` as a fraction of the height of the axes. For example, a normalized `FontSize` of 0.16 sets the text characters to a font whose height is one-tenth of the axes' height. The default units, points, are equal to 1/72 of an inch.

`FontWeight`
`light | {normal} | demi | bold`

Select bold or normal font — The character weight for all displayed graphic scale labels.

`Label`
`string`

Label text for the graphic scale — Contains a string used to label the graphic scale. The text is displayed centered on the scale. The label is often used to indicate the scale of the map, for example "1:50,000,000."

`LineWidth`
`scalar {0.5}`

Graphic scale line width — Sets the line width of the displayed scale. The value is a scalar representing points, which is 0.5 by default.

`MajorTick`
`vector`

Graphic scale major tick locations — Sets the major tick locations for the graphic scale. The default values are chosen to give a reasonably sized scale. You can specify the locations of the tick marks by providing a vector of locations. These are usually equally spaced values as generated by `start:step:end`. The values are distances in the units of the `Units` property.

`MajorTickLabel`
`Cell array of strings`

Graphic scale major tick labels — Sets the text labels associated with the major tick locations. By default, the labels are identical to the major tick locations. You can override these by providing a cell array of strings. There must be as many strings as tick locations.

`MajorTickLength`
`scalar`

Length of the major tick lines — Controls the length of the major tick lines. The length is a distance in the units of the `Units` property.

`MinorTick`
`vector`

Graphic scale minor tick locations — Sets the minor tick locations for the graphic scale. The default values are chosen to give a reasonably sized scale. You can specify the locations of the tick marks by providing a vector of locations. These are usually equally spaced values as generated by `start:step:end`. The values are distances in the units of the `Units` property.

`MinorTickLabel`
`strings`

Graphic scale minor tick labels — Sets the text labels associated with the minor tick locations. By default, the label is identical to the last minor tick location. You can override this by providing a string label.

`MinorTickLength`
`scalar`

Length of the minor tick lines — Controls the length of the minor tick lines. The length is a distance in the units of the `Units` property.

`RulerStyle`
`{ruler} | lines | patches`

Style of the graphic scale — Selects among three different kinds of graphic scale displays. The default `ruler` style looks like n axes' *x*-axis. The `lines` style has three horizontal lines across the tick marks. This type of graphic scale is often used on maps from the U.S. Geological Survey. The `patches` style has alternating black and white rectangles in place of lines and tick marks.

`TickDir`
`{up} | down`

Direction of the tick marks and text — Controls the direction in which the tick marks and text labels are drawn. In the default up direction, the tick marks and text labels are placed above the baseline, which is placed at the location given in the `XLoc` property. In the down position, the tick marks and labels are drawn below the baseline.

`TickMode`
`{auto} | manual`

Tick locations mode — Controls whether the tick locations and labels are computed automatically or are user-specified. Explicitly setting the tick labels or locations results in a `'manual'` tick mode. Setting any of the tick labels or locations to an empty matrix

resets the tick mode to `'auto'`. Setting the tick mode to `'auto'` clears any explicitly specified tick locations and labels, which are then replaced by default values.

`XLoc`
`scalar`

X-location of the graphic scale — Controls the horizontal location of the graphic scale within the axes. The location is specified in the axes Cartesian projected coordinates. Use `showaxes` to make the Cartesian grid labels visible. You can also move the graphic scale by dragging the baseline with the mouse.

`YLoc`
`scalar`

Y-location of the graphic scale — Controls the vertical location of the graphic scale within the axes. The location is specified in the axes Cartesian projected coordinates. Use `showaxes` to make the Cartesian grid labels visible. You can also move the graphic scale by dragging the baseline with the mouse.

Properties That Control Scaling

`Azimuth`
`scalar`

Azimuth of scale computation — The scale of a map varies, within the projection, with geographic location and azimuth. This property controls the azimuth along which the scaling between geographic and projected coordinates is computed. The azimuth is given in the current angle units of the map axes. The default azimuth is 0.

`Lat`
`scalar`

Latitude of scale computation — The scale of a map varies, within the projection, with geographic location and azimuth. This

property controls the geographic location at which the scaling between geographic and projected coordinates is computed. The latitude is given in the current angle units of the map axes. The default location is the center of the displayed map.

`Long`

`scalar`

Longitude of scale computation — The scale of a map varies, within the projection, with geographic location and azimuth. This property controls the geographic location at which the scaling between geographic and projected coordinates is computed. The longitude is given in the current angle units of the map axes. The default location is the center of the displayed map.

`Radius`

`Name or radius of reference sphere`

Reference sphere name or radius — The `radius` property controls the scaling between angular and surface distances. `radius` can be one of the strings supported by `km2deg`, or it can be the (numerical) radius of the desired sphere in the same units as the `Units` property. The default is `'earth'`.

`Units`

`(valid distance unit strings)`

Surface distance units — Defines the distance units displayed in the graphic scale. `Units` can be any distance unit string recognized by `unitsratio`. The distance string is also used in the last graphic scale text label.

Other Properties

`Children`

`(read-only)`

Name string of graphic scale elements — Contains the tag string assigned to the graphic elements that compose the graphic scale.

All elements of the graphic scale have hidden handles except the baseline. You do not normally need to access the elements directly.

See Also

`distance` | `surfdist` | `axesscale` | `paperscale` | `distortcalc` | `mdistort`

scatterm

Purpose

Project point markers with variable color and area

Syntax

```
scatterm(lat,lon,s,c)
scatterm(lat,lon)
scatterm(lat,lon,s)
scatterm(...,m)
scatterm(...,'filled')
scatterm(ax,...)
h = scatterm(...)
```

Description

`scatterm(lat,lon,s,c)` displays colored circles at the locations specified by the vectors `lat` and `lon` (which must be the same size). The area of each marker is determined by the values in the vector `s` (in points^2) and the colors of each marker are based on the values in `c`. `s` can be a scalar, in which case all the markers are drawn the same size, or a vector the same length as `lat` and `lon`.

When `c` is a vector the same length as `lat` and `lon`, the values in `c` are linearly mapped to the colors in the current colormap. When `c` is a `length(lat)`-by-3 matrix, the values in `c` specify the colors of the markers as RGB values. `c` can also be a color string.

`scatterm(lat,lon)` draws the markers in the default size and color.

`scatterm(lat,lon,s)` draws the markers with a single color.

`scatterm(...,m)` uses the marker *m* instead of `'o'`.

`scatterm(...,'filled')` fills the markers.

`scatterm(ax,...)` plots into axes `ax` instead of `gca`. `ax` is a handle to a map axes.

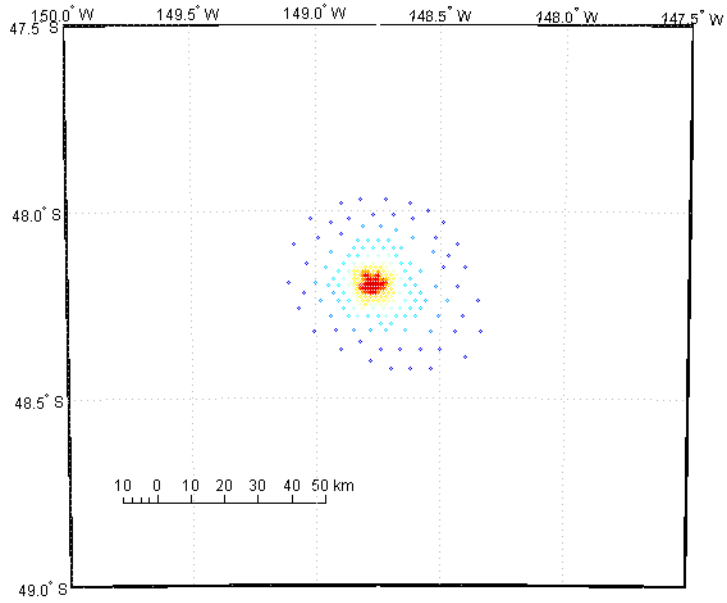
`h = scatterm(...)` returns a handle to an hggroup.

Examples

Plot the `seamount` MATLAB data as symbols with the color proportional to the height.

```
load seamount
worldmap([-49 -47.5],[-150 -147.5])
```

```
scatterm(y,x,5,z)
scaleruler
set(gca,'Visible','off')
```



See Also

stem3m

scircle1

Purpose

Small circles from center, range, and azimuth

Syntax

```
[lat,lon] = scircle1(lat0,lon0,rad)
[lat,lon] = scircle1(lat0,lon0,rad,az)
[lat,lon] = scircle1(lat0,lon0,rad,az,ellipsoid)
[lat,lon] = scircle1(lat0,lon0,rad,units)
[lat,lon] = scircle1(lat0,lon0,rad,az,units)
[lat,lon] = scircle1(lat0,lon0,rad,az,ellipsoid,units)
[lat,lon] = scircle1(lat0,lon0,rad,az,ellipsoid,units,npts)
[lat,lon] = scircle1(track,...)
```

Description

`[lat,lon] = scircle1(lat0,lon0,rad)` computes small circles (on a sphere) with a center at the point `lat0,lon0` and radius `rad`. The inputs can be scalar or column vectors. The input radius is in degrees of arc length on a sphere.

`[lat,lon] = scircle1(lat0,lon0,rad,az)` uses the input `az` to define the small circle arcs computed. The arc azimuths are measured clockwise from due north. If `az` is a column vector, then the arc length is computed from due north. If `az` is a two-column matrix, then the small circle arcs are computed starting at the azimuth in the first column and ending at the azimuth in the second column. If `az = []`, then a complete small circle is computed.

`[lat,lon] = scircle1(lat0,lon0,rad,az,ellipsoid)` computes small circles on the ellipsoid defined by the input `ellipsoid`, rather than by assuming a sphere. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. If the semimajor axis is non-zero, `rad` is assumed to be in distance units matching the units of the semimajor axis. However, if `ellipsoid = []`, or if the semimajor axis is zero, then `rad` is interpreted as an angle and the small circles are computed on a sphere as in the preceding syntax.

`[lat,lon] = scircle1(lat0,lon0,rad,`*`units`*`)`,
`[lat,lon] = scircle1(lat0,lon0,rad,az,`*`units`*`)`, and
`[lat,lon] = scircle1(lat0,lon0,rad,az,ellipsoid,`*`units`*`)`
are all valid calling forms, which use the input string *`units`* to define

the angle units of the inputs and outputs. If the *units* string is omitted, 'degrees' is assumed.

[lat,lon] = scircle1(lat0,lon0,rad,az,ellipsoid,*units*,npts) uses the scalar input npts to determine the number of points per small circle computed. The default value of npts is 100.

[lat,lon] = scircle1(*track*,...) uses the *track* string to define either a great circle or rhumb line radius. If *track* = 'gc', then small circles are computed. If *track* = 'rh', then the circles with radii of constant rhumb line distance are computed. If the *track* string is omitted, 'gc' is assumed.

mat = scircle1(...) returns a single output argument where mat = [lat lon]. This is useful if a single small circle is computed.

Multiple circles can be defined from a single starting point by providing scalar lat0,lon0 inputs and column vectors for rad and az if desired.

Definitions

A *small circle* is the locus of all points an equal surface distance from a given center. For true small circles, this distance is always calculated in a great circle sense; however, the scircle1 function allows a locus to be calculated using distances in a rhumb line sense as well. An example of a small circle is *all points exactly 100 miles from the Washington Monument*. Parallels on the globe are all small circles. Great circles are a subset of small circles, specifically those with a radius of 90º or its angular equivalent, so all meridians on the globe are small circles as well.

Small circle notation consists of a center point and a radius in units of angular arc length.

Examples

Create and plot a small circle centered at (0º,0º) with a radius of 10º.

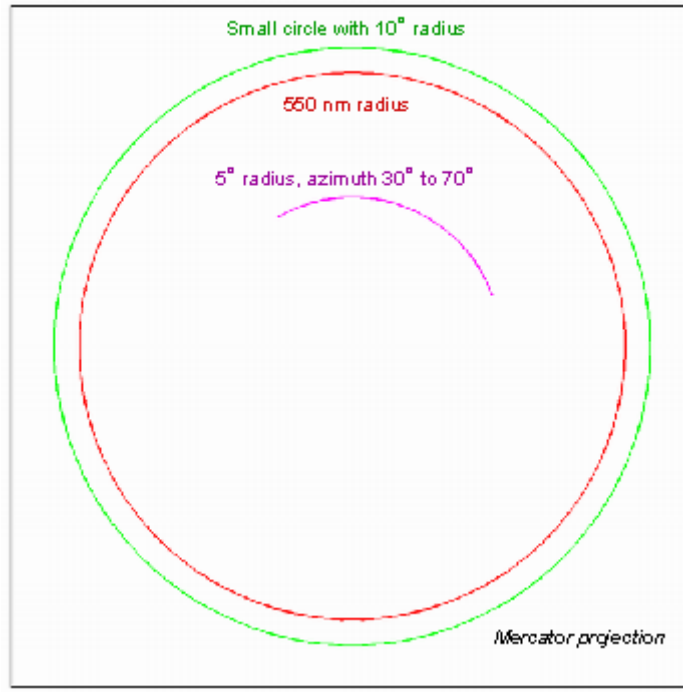
```
axesm('mercator','MapLatLimit',[-30 30],'MapLonLimit',[-30 30]);
[latc,longc] = scircle1(0,0,10);
plotm(latc,longc,'g')
```

If the desired radius is known in some nonangular distance unit, use the radius returned by the `earthRadius` function as the ellipsoid input to set the range units. (Use an empty azimuth entry to indicate a full circle.)

```
[latc,longc] = scircle1(0,0,550,[],earthRadius('nm'));
plotm(latc,longc,'r')
```

For just an arc of the circle, enter an azimuth range.

```
[latc,longc] = scircle1(0,0,5,[-30 70]);
plotm(latc,longc,'m')
```



See Also

`scircle2` | `scircleg` | `track` | `trackg` | `track1` | `track2`

Purpose

Small circles from center and perimeter

Syntax

```
[lat,lon] = scircle2(lat1,lon1,lat2,lon2)
[lat,lon] = scircle2(lat1,lon1,lat2,lon2,ellipsoid)
[lat,lon] = scircle2(lat1,lon1,lat2,lon2,units)
[lat,lon] = scircle2(lat1,lon1,lat2,lon2,ellipsoid,units)
[lat,lon] = scircle2(lat1,lon1,lat2,lon2,ellipsoid,units,
   npts)
[lat,lon] = scircle2(track,...)
mat = scircle2(...)
mat = [lat lon]
```

Description

`[lat,lon] = scircle2(lat1,lon1,lat2,lon2)` computes small circles (on a sphere) with centers at the points `lat1,lon1` and points on the circles at `lat2,lon2`. The inputs can be scalar or column vectors.

`[lat,lon] = scircle2(lat1,lon1,lat2,lon2,ellipsoid)` computes the small circle on the ellipsoid defined by the input `ellipsoid`, rather than by assuming a sphere. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. Default is a unit sphere.

`[lat,lon] = scircle2(lat1,lon1,lat2,lon2,`*`units`*`)` and `[lat,lon] = scircle2(lat1,lon1,lat2,lon2,ellipsoid,`*`units`*`)` are valid calling forms, which use the input string *`units`* to define the angle units of the inputs and outputs. If the input string *`units`* is omitted, `'degrees'` is assumed.

`[lat,lon] = scircle2(lat1,lon1,lat2,lon2,ellipsoid,`*`units`*`,npts)` uses the scalar input `npts` to determine the number of points per track computed. The default value of `npts` is 100.

`[lat,lon] = scircle2(`*`track`*`,...)` uses the *`track`* string to define either a great circle or a rhumb line radius. If *`track`*`' = 'gc'`, then small circles are computed. If *`track`* `= 'rh'`, then circles with radii of constant rhumb line distance are computed. If the *`track`* string is omitted, `'gc'` is assumed.

`mat = scircle2(...)` returns a single output argument where `mat = [lat lon]`. This is useful if a single circle is computed.

Multiple circles can be defined from a single center point by providing scalar `lat1,lon1` inputs and column vectors for the points on the circumference, `lat2,lon2`.

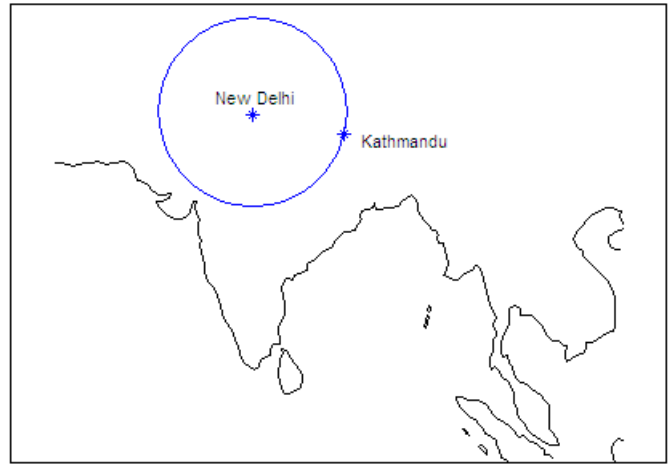
Definitions

A *small circle* is the locus of all points an equal surface distance from a given center. For true small circles, this distance is always calculated in a great circle sense. However, the `scircle2` function allows a locus to be calculated using distances in a rhumb line sense as well. An example of a small circle is *all points exactly 100 miles from the Washington Monument*.

Examples

Plot the locus of all points the same distance from New Delhi as Kathmandu:

```
axesm('mercator','MapLatlimit',[0 40],'MapLonLimit',[60 110]);
load coast

% For reference
plotm(lat,long,'k');

% New Delhi
lat1 = 29; lon1 = 77.5;

% Kathmandu
lat2 = 27.6; lon2 = 85.5;

% Plot the cities
plotm([lat1 lat2],[lon1 lon2],'b*')
[latc,lonc] = scircle2(lat1,lon1,lat2,lon2);
plotm(latc,lonc,'b')
```



See Also

`scircle1` | `track` | `track1` | `track2`

scircleg

Purpose

Small circle defined via mouse input

Syntax

```
h = scircleg(ncirc)
h = scircleg(ncirc,npts)
h = scircleg(ncirc,linestyle)
h = scircleg(ncirc,PropertyName,PropertyValue,...)
[lat,lon] = scircleg(ncirc,npts,...)
h = scircleg(track,ncirc,...)
```

Description

`h = scircleg(ncirc)` brings forward the current map axes and waits for the user to make (2 * `ncirc`) mouse clicks. The output `h` is a vector of handles for the `ncirc` small circles, which are then displayed.

`h = scircleg(ncirc,npts)` specifies the number of plotting points to be used for each small circle. `npts` is 100 by default.

`h = scircleg(ncirc,linestyle)` specifies the line style for the displayed small circles, where *`linestyle`* is any line style string recognized by the standard MATLAB function `line`.

`h = scircleg(ncirc,PropertyName,PropertyValue,...)` allows property name/property value pairs to be set, where *`PropertyName`* and `PropertyValue` are recognized by the `line` function.

`[lat,lon] = scircleg(ncirc,npts,...)` returns the coordinates of the plotted points rather than the handles of the small circles. Successive circles are stored in separate columns of `lat` and `lon`.

`h = scircleg(track,ncirc,...)` specifies the logic with which ranges are calculated. If the string track is `'gc'` (the default), great circle distance is used. If track is `'rh'`, rhumb line distance is used.

This function is used to define small circles for display using mouse clicks. For each circle, two clicks are required: one to mark the center of the circle and one to mark any point on the circle itself, thereby defining the radius.

Background

A small circle is the locus of all points an equal surface distance from a given center. For true small circles, this distance is always calculated

in a great circle sense; however, the `scircleg` function allows a locus to be calculated using distances in a rhumb line sense as well. You can modify the circle after creation by **shift**+clicking it. The circle is then in edit mode, during which you can change the size and position by dragging control points, or by entering values into a control panel. **Shift**+clicking again exits edit mode.

See Also

`scircle1` | `scircle2`

Purpose

Intersection points for pairs of small circles

Syntax

```
[newlat,newlon] = scxsc(lat1,lon1,range1,lat2,lon2,range2)
[newlat,newlon]=scxsc(lat1,lon1,range1,lat2,lon2,range2,
   units)
```

Description

`[newlat,newlon] = scxsc(lat1,lon1,range1,lat2,lon2,range2)` returns in `newlat` and `newlon` the locations of the points of intersection of two small circles in *small circle notation*. For example, the first small circle in a pair would be centered on the point (`lat1`,`lon1`) with a radius of `range1` (in angle units). The inputs must be column vectors. If the circles do not intersect, or are identical, two `NaN`s are returned and a warning is displayed. If the two circles are tangent, the single intersection point is returned twice.

`[newlat,newlon]=scxsc(lat1,lon1,range1,lat2,lon2,range2,`*`units`*`)` specifies the angle units used for all inputs, where *`units`* is any valid angle units string. The default units are '*`degrees`*'.

For any pair of small circles, there are four possible intersection conditions: the circles are identical, they do not intersect, they are tangent to each other and hence they intersect once, or they intersect twice.

Small circle notation consists of a center point and a radius in units of angular arc length.

Examples

Given a small circle centered at (10ºS,170ºW) with a radius of 20º (~1200 nautical miles), where does it intersect with a small circle centered at (3ºN, 179ºE), with a radius of 15º (~900 nautical miles)?

```
[newlat,newlong] = scxsc(-10,-170,20,3,179,15)

newlat =
   -8.8368    9.8526
newlong =
   169.7578 -167.5637
```

Note that in this example, the two small circles cross the date line.

Tips

Great circles are a subset of small circles—a great circle is just a small circle with a radius of 90º. This provides two methods of notation for defining great circles. *Great circle notation* consists of a point on the circle and an azimuth at that point. *Small circle notation* for a great circle consists of a center point and a radius of 90º (or its equivalent in radians).

See Also

`gc2sc` | `gcxgc` | `gcxsc` | `rhxrh` | `crossfix` | `polyxpoly`

sdtsdemread

Purpose

Read data from SDTS raster/DEM data set

Syntax

```
[Z, R] = sdtsdemread(filename)
```

Description

`[Z, R] = sdtsdemread(filename)` reads data from an SDTS DEM data set. `Z` is a matrix containing the elevation values. `R` is a referencing matrix (see `makerefmat`). `NaNs` are assigned to elements of `Z` corresponding to null data values or fill data values in the cell module.

`filename` can be the name of the SDTS catalog directory file (`*CATD.DDF`) or the name of any of the other files in the data set. `filename` can include the directory name; otherwise `filename` is searched for in the current directory and the MATLAB path. If any of the files specified in the catalog directory are missing, `sdtsdemread` fails.

Tips

Elevation values can be imported with `sdtsdemread` from DEMs that use the SPRE Raster Profile (in use since January, 2001) as well as from older SDTS DEM data sets. Under this profile, elevations can be encoded either as 32-bit floating-point numbers (when their units are "decimal meters"), or as 16-bit integers (when units are "feet" or "meters"). The output class from sdtsdemread for both types of elevation encoding is `double`.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: http://www.mathworks.com/help/map/finding-geospatial-data.html .

Examples

```
[Z, R] = sdtsdemread('9129CATD.ddf');
mapshow(Z,R,'DisplayType','contour')
```

See Also

`arcgridread` | `makerefmat` | `mapshow` | `sdtsinfo`

Purpose

Information about SDTS data set

Syntax

```
info = sdtsinfo(filename)
```

Description

`info = sdtsinfo(filename)` returns a structure whose fields contain information about the contents of a SDTS data set.

`filename` is a string that specifies the name of the SDTS catalog directory file, such as `7783CATD.DDF`. The filename can also include the directory name. If `filename` does not include the directory, then it must be in the current directory or in a directory on the MATLAB path. If `sdtsinfo` cannot find the SDTS catalog file, it returns an error.

If any of the other files in the data set as specified by the catalog file is missing, a warning message is returned. Subsequent calls to read data from the file might also fail.

Field Descriptions

The `info` structure contains the following fields:

`Filename`	String containing the name of the catalog directory file of the SDTS transfer set
`Title`	String containing the name of the data set
`ProfileID`	String containing the Profile Identifier, e.g., `'SRPE: SDTS RASTER PROFILE and EXTENSIONS'`
`ProfileVersion`	String containing the Profile Version Identifier, e.g., `'VER 1.1 1998 01'`
`MapDate`	String specifying the date associated with the cartographic information contained in the data set
`DataCreationDate`	String specifying the creation date of the data set
`HorizontalDatum`	String representing the horizontal datum to which the data is referenced

`MapRefSystem`	String describing the projection and reference system used: `'GEO'`, `'SPCS'`, `'UTM'`, `'UPS'`, or `''`
`ZoneNumber`	Scalar value representing the zone number
`XResolution`	Scalar value representing the X component of the horizontal coordinate resolution
`YResolution`	Scalar value representing the Y component of the horizontal coordinate resolution
`NumberOfRows`	Scalar value representing the number of rows of the DEM
`NumberOfCols`	Scalar value representing the number of columns of the DEM
`HorizontalUnits`	String specifying the units used for the horizontal coordinate values
`VerticalUnits`	String specifying the units used for the vertical coordinate values
`MinElevation`	Scalar value of the minimum elevation value for the data set
`MaxElevation`	Scalar value of the maximum elevation value for the data set

Examples

```
info = sdtsinfo('9129CATD.DDF');
```

See Also

`sdtsdemread` | `makerefmat`

Purpose

Sector of small circle defined via mouse input

Syntax

```
sectorg
```

Description

`sectorg` prompts the user to indicate by two successive mouse clicks two points that define the center and radius of a small circle arc. By default, the angular width of the sector is 60º. The sector is constructed using the vector defined by the mouse clicks as the reference azimuth (defined to run through the center of the sector).

Once a sector has been drawn, **Shift**+clicking on it displays four control points (center point, arc resize, radial resize, and rotation controls), and the associated **Sector** control window. You can graphically interact with sectors as follows:

- To translate the circle, click and drag the center (o) control.
- To change the arc size, click and drag the resize control (square).
- To change the radial size of the sector, click and drag the radial control (down triangle).
- To rotate the arc, click and drag the rotation control (x).

You can also modify a selected sector by entering the appropriate values in the **Sector** control window and then pressing **Enter** or clicking the **Close** button. Display of the control panel is toggled by **Shift**+clicking the sector. If you select multiple sectors, a separate **Sector** control window will appear for each one.

Tips

Sector control windows are superimposed at the same location. A valid map axes must exist prior to running this function.

See Also

`scircleg` | `trackg`

setltln

Purpose

Convert data grid rows and columns to latitude-longitude

Syntax

```
[lat, lon] = setltln(Z, R, row, col)
[lat, lon, indxPointOutsideGrid] = setltln(Z, R, row, col)
latlon = setltln(Z, R, row, col)
```

Description

`[lat, lon] = setltln(Z, R, row, col)` returns the latitude and longitudes associated with the input row and column coordinates of the regular data grid `Z`. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Points falling outside the grid are ignored in `row` and `col`. All input angles are in degrees.

`[lat, lon, indxPointOutsideGrid] = setltln(Z, R, row, col)` returns the indices of the elements of the `row` and `col` vectors that lie outside the input grid. The outputs `lat` and `lon` always ignore these points; the third output accounts for them.

`latlon = setltln(Z, R, row, col)` returns the coordinates in a single two-column matrix of the form `[latitude longitude]`.

Examples

Find the coordinates of row 45, column 65 of `topo`:

```
load topo
[lat,lon,indxPointOutsideGrid] = setltln(topo,topolegend,45,65)

lat =
  -45.5000
lon =
   64.5000
indxPointOutsideGrid = [] % Empty because the point is valid
```

See Also

`ltln2val` | `pix2latlon` | `setpostn`

setm

Purpose

Set properties of map axes and graphics objects

Syntax

```
setm(h,MapAxesPropertyName,PropertyValue,...)
setm(texthndl,'MapPosition',position)
setm(surfhndl,'Graticule',lat,lon,alt)
setm(surfhndl,'MeshGrat',npts,alt)
```

Description

`setm(h,MapAxesPropertyName,PropertyValue,...)`, where `h` is a valid map axes handle, sets the map axes properties specified in the input list. The map axes properties must be recognized by `axesm`.

`setm(texthndl,'MapPosition',position)` alters the position of the projected text object specified by its handle to the `[latitude longitude]` or the `[latitude longitude altitude]` specified by the position vector.

`setm(surfhndl,'Graticule',lat,lon,alt)` alters the graticule of the projected surface object specified by its handle. The graticule is specified by the latitude and longitude matrices, specifying locations of the graticule vertices. The altitude can be specified by a scalar, or by a matrix providing a value for each vertex.

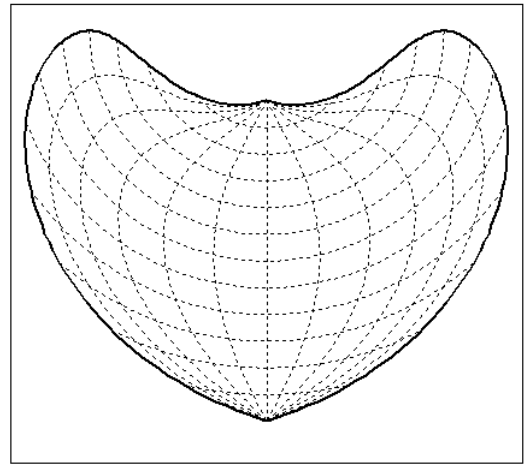
`setm(surfhndl,'MeshGrat',npts,alt)` alters the mesh graticule of projected surface objects displayed using the `meshm` function. In this case, the two-element vector `npts` specifies the graticule size in the manner described under `meshm`. The altitude can be a scalar or a matrix with a size corresponding to `npts`.

Examples

Display a map axes and alter it:

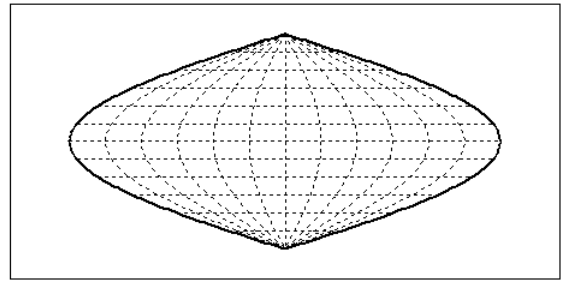
```
axesm('bonne','Frame','on','Grid','on')
```

The standard Bonne projection has a standard parallel at 30ºN.



Setting this standard parallel to 0º results in a Sinusoidal projection:

```
setm(gca,'MapParallels',0)
```



See Also

`axesm` | `getm`

setpostn

Purpose

Convert latitude-longitude to data grid rows and columns

Syntax

```
[row, col] = setpostn(Z, R, lat, lon)
indx = setpostn(...)
[row, col, indxPointOutsideGrid] = setpostn(...)
```

Description

`[row, col] = setpostn(Z, R, lat, lon)` returns the row and column indices of the regular data grid `Z` for the points specified by the vectors `lat` and `lon`. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. Points falling outside the grid are ignored in `row` and `col`. All input angles are in degrees.

`indx = setpostn(...)` returns the indices of `Z` corresponding to the points in `lat` and `lon`. Points falling outside the grid are ignored in `indx`.

`[row, col, indxPointOutsideGrid] = setpostn(...)` returns the indices of `lat` and `lon` corresponding to points outside the grid. These points are ignored in `row` and `col`.

Examples

What are the matrix coordinates in `topo` of Denver, Colorado, at (39.7ºN,105ºW)?

```
load topo
[row,col] = setpostn(topo,topolegend,39.7,105)

row =
   130
col =
   105
```

See Also

latlon2pix | ltln2val | setltln

shaderel

Purpose

Construct `cdata` and colormap for shaded relief

Syntax

```
[cindx,cimap,clim] = shaderel(X,Y,Z,cmap)
[cindx,cimap,clim] = shaderel(X,Y,Z,cmap,[azim elev])
[cindx,cimap,clim] = shaderel(X,Y,Z,cmap,[azim elev],cmapl)
[cindx,cimap,clim] = shaderel(X,Y,Z,cmap,[azim elev],cmapl,
   clim)
```

Description

`[cindx,cimap,clim] = shaderel(X,Y,Z,cmap)` constructs the colormap and color indices to allow a surface to be displayed in colored shaded relief. The colors are proportional to the magnitude of `Z`, but modified by shades of gray based on the surface normals to simulate surface lighting. This representation allows both large and small-scale differences to be seen. `X`, `Y`, and `Z` define the surface. `cmap` is the colormap used to create the new shaded colormap `cimap`. `cindx` is a matrix of color indices to `cimap`, based on the elevation and surface normal of the `Z` matrix element. `clim` contains the color axis limits.

`[cindx,cimap,clim] = shaderel(X,Y,Z,cmap,[azim elev])` places the light at the specified azimuth and elevation. By default, the direction of the light is East (90º azimuth) at an elevation of 45º.

`[cindx,cimap,clim] = shaderel(X,Y,Z,cmap,[azim elev],cmapl)` chooses the number of grays to give a `cimap` of length `cmapl`. By default, the number of grayscales is chosen to keep the shaded colormap below 256. If the vector of azimuth and elevation is empty, the default locations are used.

`[cindx,cimap,clim] = shaderel(X,Y,Z,cmap,[azim elev],cmapl,clim)` uses the color limits to index `Z` into `cmap`.

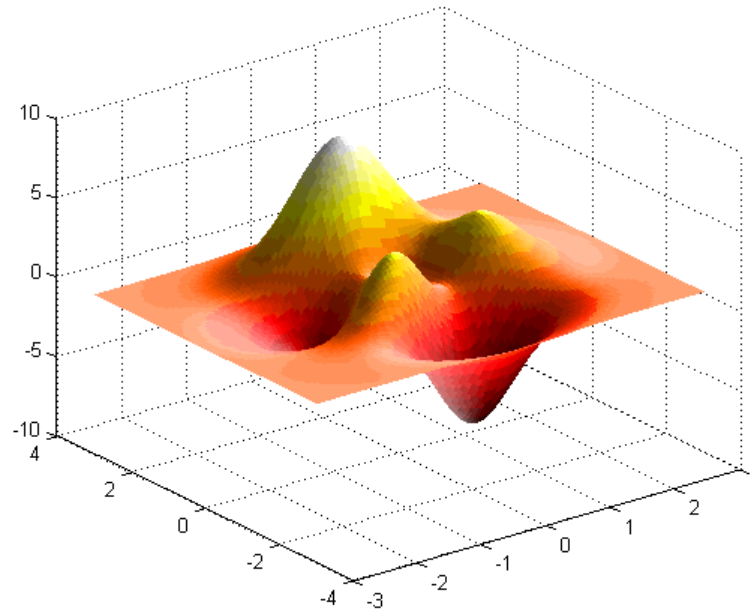
Tips

This function effectively multiplies two colormaps, one with color based on elevation, the other with a grayscale based on the slope of the surface, to create a new colormap. This produces an effect similar to using a light on a surface, but with all of the visible colors actually in the colormap. Lighting calculations are performed on the unprojected data.

Examples

Display the `peaks` surface with a shaded colormap:

```
[X,Y,Z] = peaks(100);
cmap = hot(16);
[cindx,cimap,clim] = shaderel(X,Y,Z,cmap);
surf(X,Y,Z,cindx); colormap(cimap); caxis(clim)
shading flat
```



See Also

`caxis` | `colormap` | `light` | `meshlsrm` | `surf` | `surflsrm`

shapeinfo

Purpose

Information about shapefile

Syntax

```
info = shapeinfo(filename)
```

Description

`info = shapeinfo(filename)` returns a structure, `info`, whose fields contain information about the contents of a shapefile. `filename` can be the base name or the full name of any one of the component files. `shapeinfo` reads all three files as long as they exist in the same folder and the unit of length or angle is not specified. If the main file (with extension `.SHP`) is missing, `shapeinfo` returns an error. If either of the other files is missing, `shapeinfo` returns a warning.

Tips

`shapeinfo` cannot tell you which coordinate system the data in a shapefile uses. Coordinates can be either planar (*x*, *y*) or geographic (*lat*, *lon*) and have a variety of units. This information can be critical to the proper display of shapefile vector data. For more information on this topic, see "Mapstructs and Geostructs".

Output Arguments

The `info` structure contains the following fields:

`Filename`	Char array containing the names of the files that were read
`ShapeType`	String containing the shape type
`BoundingBox`	Numerical array of size 2-by-N that specifies the minimum (row 1) and maximum (row 2) values for each dimension of the spatial data in the shapefile
`Attributes`	Structure array of size 1-by-`numAttributes` that describes the attributes of the data
`NumFeatures`	The number of spatial features in the shapefile

The `Attributes` structure contains these fields:

`Name`	String containing the attribute name as given in the xBASE table
`Type`	String specifying the MATLAB class of the attribute data returned by `shaperead`. The following attribute (xBASE) types are supported: Numeric, Floating, Character, and Date.

See Also

`shaperead | shapewrite`

How To

- "Mapping Toolbox Geographic Data Structures"

shaperead

Purpose

Read vector features and attributes from shapefile

Syntax

```
S = shaperead(filename)
S = shaperead(filename, Name,Value, ...)
[S, A] = shaperead(...)
```

Description

`S = shaperead(filename)` reads in a shapefile, `filename`, and returns an *N*-by-1 geographic data structure array in projected map coordinates (a mapstruct). The geographic data structure combines geometric and feature attribute information. `shaperead` supports the ordinary 2-D shape types: `'Point'`, `'Multipoint'`, `'PolyLine'`, and `'Polygon'`.

`S = shaperead(filename, Name,Value, ...)` returns a subset of the shapefile contents in `S`, as determined by the parameters. The geographic data structure, `S`, is a mapstruct unless `UseGeoCoords` is `true`. If you do not specify any parameters, `shaperead` returns an entry for every non-null feature and creates a field for every attribute.

`[S, A] = shaperead(...)` returns an *N*-by-1 geographic data structure array, `S`, containing geometric information, and a parallel *N*-by-1 attribute structure array, `A`, containing feature attribute information.

Input Arguments

filename

Refers to the base name or full name of one of the component files in a shapefile. If the main file (with extension .shp) is missing, `shaperead` throws an error. If either of the other files is missing, `shaperead` issues a warning.

Make sure that your machine is set to the same character encoding scheme as the data you are importing. For example, if you are trying to import a shapefile that contains Japanese characters, configure your machine to support the `Shift-JIS` encoding scheme.

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding

value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

RecordNumbers

Integer-valued vector of class `double`. Use the parameter `RecordNumbers` to import only features with listed record numbers.

Use the parameters `RecordNumbers`, `BoundingBox`, and `Selector` to select which features to read. If you use more than one of these parameters in the same call, you receive the intersection of the records that match the individual specifications. For instance, if you specify values for both `RecordNumbers` and `BoundingBox`, you import only those features with record numbers that appear in your list and that also have bounding boxes intersecting the specified bounding box.

BoundingBox

2-by-2 array of class `double`. Use the parameter `BoundingBox` to import only features whose bounding boxes intersect the specified box. The `shaperead` function does not trim features that partially intersect the box.

Selector

Cell array containing a function handle and one or more attribute names. (The function must return a `logical` scalar.) Use the `Selector` parameter to import only features for which the function, when applied to the corresponding attribute values, returns `true`.

Attributes

Cell array of attribute names. Use the parameter `Attributes` to include listed attributes and set the order of attributes in the structure array. Use `{}` to omit all attributes.

UseGeoCoords

`Logical` scalar that specifies returning shapefile contents in a geostruct, if set to `true`. Use this parameter when you know that the *x*- and *y*-coordinates in the shapefile actually represent longitude and latitude data. (If you do not know whether you are working with geographic or map coordinates, see "Mapstructs and Geostructs" in the User's Guide.)

Default: `false`

Output Arguments

S

An *N*-by-1 geographic data structure array containing an element for each non-null, spatial feature in the shapefile.

A

An *N*-by-1 attribute structure array, `A`, parallel to array `S`.

The fields in the output structure arrays `S` and `A` depend on (1) the type of shape contained in the file and (2) the names and types of attributes included in the file. The `shaperead` function supports the following four attribute types: `numeric` and `floating` (stored as type `double` in MATLAB) and `character` and `date` (stored as `char array`).

Examples

Read a shapefile of Concord roads and analyze the data.

```
% Read the entire concord_roads.shp shapefile, including
% the attributes, in concord_roads.dbf.
S = shaperead('concord_roads.shp')
```

Your output appears as follows:

```
S =

609x1 struct array with fields:
    Geometry
    BoundingBox
    X
    Y
```

```
    STREETNAME
    RT_NUMBER
    CLASS
    ADMIN_TYPE
    LENGTH
```

You have a mapstruct with `X` and `Y` coordinate vectors.

```
% Restrict output based on bounding box and read only two
% of the feature attributes.
bbox = [2.08 9.11; 2.09 9.12] * 1e5;
S = shaperead('concord_roads','BoundingBox',bbox,...
              'Attributes',{'STREETNAME','CLASS'})
```

Your output appears as follows:

```
S =

87x1 struct array with fields:
    Geometry
    BoundingBox
    X
    Y
    STREETNAME
    CLASS

% Select the class 4 and higher road segments that are at least 200
% meters in length.  Note the use of an anonymous function in the
% selector.
S = shaperead('concord_roads.shp','Selector',...
           {@(v1,v2) (v1 >= 4) && (v2 >= 200),'CLASS','LENGTH'})
```

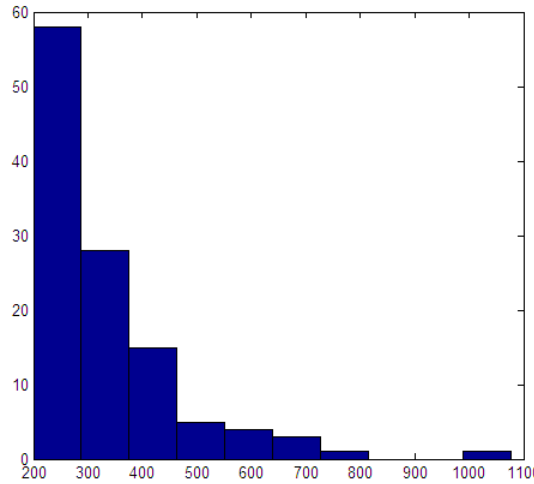
Your output appears as follows:

```
S =

115x1 struct array with fields:
    Geometry
```

```
    BoundingBox
    X
    Y
    STREETNAME
    RT_NUMBER
    CLASS
    ADMIN_TYPE
    LENGTH

% Determine the number of roads of each class.
N = hist([S.CLASS],1:7)
```

Your output appears as follows:

```
N =

     0     0     0     7    93    15     0

% Display a histogram of the number of roads
% that fall in each category of length.
hist([S.LENGTH])
```



Read a shapefile of worldwide city names and locations in latitude and longitude.

```
S = shaperead('worldcities.shp', 'UseGeoCoords', true)
```

Your output appears as follows:

```
S =
318x1 struct array with fields:
    Geometry
    Lon
    Lat
    Name
```

You set `'UseGeoCoords'` to `true`, so you received a geostruct.

See Also

`shapeinfo` | `shapewrite`

How To

- “Mapping Toolbox Geographic Data Structures”

Related Links

- http://www.mathworks.com/help/map/finding-geospatial-data.html

Purpose

Write geographic data structure to shapefile

Syntax

```
shapewrite(S, filename)
shapewrite(S, filename, 'DbfSpec', dbfspec)
```

Description

`shapewrite(S, filename)` writes a geographic data structure to disk in shapefile format. `shapewrite` creates three output files: `[basename '.shp']`, `[basename '.shx']`, and `[basename '.dbf']`, where `basename` is `filename` without its extension. If a given attribute is integer-valued for all features, then it is written to the `[basename '.dbf']` file as an integer. If an attribute is non-integer-valued for any feature, then it is written as a fixed point decimal value with six digits to the right of the decimal place.

`shapewrite(S, filename, 'DbfSpec', dbfspec)` writes a shapefile in which the content and layout of the DBF file is controlled by a DBF specification, indicated here by the parameter value `dbfspec`.

Tips

- The xBASE (`.dbf`) file specifications require that geostruct and mapstruct attribute names are truncated to 11 characters when copied as DBF field names. Consider shortening long field names before calling `shapewrite`. By doing this, you make field names in the DBF file more readable and avoid introducing duplicate names as a result of truncation.
- Remember to set your character encoding scheme to match that of the geographic data structure you are exporting. For instance, if you are exporting a map that displays Japanese text, configure your machine to support `Shift-JIS` character encoding.

Input Arguments

S

A valid mapstruct or geostruct with specific restrictions on its attribute fields:

- Each attribute field value must be either a real, finite, scalar double or a character string.
- The type of a given attribute must be consistent across all features.

filename

A character string specifying the output file name and location. If an extension is included, it must be `'.shp'` or `'.SHP'`.

'DbfSpec', dbfspec

A scalar MATLAB structure containing one field for each feature attribute to be included in the output shapefile. To include an attribute in the output, provide a field in `dbfspec` with a name identical to the attribute name as given in `S`. Assign to that field a scalar structure with the following four fields:

- `FieldName` — The field name to be used in the file
- *`FieldType`* — The field type to be used in the file (`'N'` or `'C'`)
- `FieldLength` — The field length in the file, in bytes
- `FieldDecimalCount` — For numeric fields, the number of digits to the right of the decimal place

Call `makedbfspec` to construct a DBF spec. Modify the output to remove attributes or change the `FieldName`, `FieldLength`, or `FieldDecimalCount` for one or more attributes.

Examples

Derive a shapefile from `concord_roads.shp` in which roads of `CLASS 5` and greater are omitted. Note the use of the `'Selector'` option in `shaperead`, together with an anonymous function, to read only the main roads from the original shapefile.

```
shapeinfo('concord_roads')  % 609 features

ans =
       Filename: [3x67 char]
      ShapeType: 'PolyLine'
    BoundingBox: [2x2 double]
    NumFeatures: 609
     Attributes: [5x1 struct]
```

```
S = shaperead('concord_roads', 'Selector', ...
    {@(roadclass) roadclass < 4, 'CLASS'});
shapewrite(S, 'main_concord_roads.shp')
shapeinfo('main_concord_roads')  % 107 features

ans =
       Filename: [3x24 char]
      ShapeType: 'PolyLine'
    BoundingBox: [2x2 double]
    NumFeatures: 107
     Attributes: [5x1 struct]
```

See Also

makedbfspec | shapeinfo | shaperead

How To

- "Mapping Toolbox Geographic Data Structures"

showaxes

Purpose

Toggle display of map coordinate axes

Syntax

```
showaxes(action)
showaxes
```

Description

`showaxes(action)` modifies the Cartesian axes based on the value of *`action`*, as defined in the Inputs section below.

`showaxes` toggles between displaying the default axes ticks on the MATLAB Cartesian axes and removing the axes ticks.

Input Arguments

action

A string or RGB triple that specifies how to modify the Cartesian axes

Value	Data Type	Action
`'on'`	string	Displays the MATLAB Cartesian axes and default axes ticks
`'off'`	string	Removes the axes ticks from the MATLAB Cartesian axes
`'hide'`	string	Hides the Cartesian axes
`'show'`	string	Shows the Cartesian axes
`'reset'`	string	Sets the Cartesian axes to the default settings
`'boxoff'`	string	Removes axes ticks, color, and box from the Cartesian axes
`colorstr`	string	Sets the Cartesian axes to the color specified by *`colorstr`*
`colorvec`	RGB triple	Uses *`colorvec`* to set the Cartesian axes color

See Also

`axesm`

Purpose

Specify graphic objects to display on map axes

Syntax

```
showm
showm(handle)
showm(object)
```

Description

`showm` brings up a dialog box for selecting the objects to show (set their `Visible` property to `'on'`).

`showm(handle)` shows the objects specified by a vector of handles.

`showm(object)` shows those objects specified by the *`object`* string, which can be any string recognized by the `handlem` function.

See Also

`clma` | `clmo` | `handlem` | `hidem` | `namem` | `tagm`

sizem

Purpose

Row and column dimensions needed for regular data grid

Syntax

```
[r,c] = sizem(latlim,lonlim,scale)
rc = sizem(latlim,lonlim,scale)
[r,c,refvec] = sizem(latlim,lonlim,scale)
```

Description

`[r,c] = sizem(latlim,lonlim,scale)` returns the required size for a regular data grid lying between the latitude and longitude limits specified by the two-element input vectors `latlim` and `lonlim`, which are of the form `[south-limit north-limit]` and `[west-limit and east-limit]`, respectively. The `scale` is the desired cells-per-degree measure of the desired data grid.

`rc = sizem(latlim,lonlim,scale)` returns the size of the matrix in one two-element vector.

`[r,c,refvec] = sizem(latlim,lonlim,scale)` also returns the three-element referencing vector geolocating the desired regular data grid.

Examples

How large a matrix would be required for a map of the world at a scale of 25 matrix cells per degree? (That's 25x25=625 cells per "square" degree.)

```
[r,c] = sizem([90,-90],[-180,180],25)

r =
        4500
c =
        9000
```

Bear in mind for memory purposes — 9000 x 4500 = 4.05 x 10^7 entries!

See Also

`findm` | `limitm` | `nanm` | `onem` | `spzerom` | `zerom`

Purpose

Convert distance from statute miles to degrees

Syntax

```
deg = sm2deg(sm)
deg = sm2deg(sm,radius)
deg = sm2deg(sm,sphere)
```

Description

`deg = sm2deg(sm)` converts distances from statute miles to degrees as measured along a great circle on a sphere with a radius of 6371 km (3958.748 sm), the mean radius of the Earth.

`deg = sm2deg(sm,radius)` converts distances from statute miles to degrees as measured along a great circle on a sphere having the specified radius. `radius` must be in units of statute miles.

`deg = sm2deg(sm,sphere)` converts distances from statute miles to degrees, as measured along a great circle on a sphere approximating an object in the Solar System. *`sphere`* may be one of the following strings: `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'earth'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, or `'pluto'`, and is case-insensitive.

See Also

`degtorad` | `radtodeg` | `deg2km` | `km2rad` | `km2nm` | `km2sm` | `deg2nm` | `nm2deg` | `nm2km` | `nm2sm` | `deg2sm` | `sm2km` | `sm2nm`

sm2km

Purpose

Convert statute miles to kilometers

Syntax

```
km = sm2km(sm)
```

Description

`km = sm2km(sm)` converts distances from statute miles to kilometers.

See Also

`deg2km` | `km2deg` | `km2rad` | `rad2km` | `deg2nm` | `nm2deg` | `nm2rad` | `rad2nm` | `deg2sm` | `sm2deg` | `deg2sm` | `sm2rad` | `rad2sm`

Purpose

Convert statute to nautical miles

Syntax

```
nm = sm2nm(sm)
```

Description

`nm = sm2nm(sm)` converts distances from statute to nautical miles.

See Also

`deg2km` | `km2deg` | `km2rad` | `rad2km` | `deg2nm` | `nm2deg` | `nm2rad` | `rad2nm` | `deg2sm` | `sm2deg` | `deg2sm` | `sm2rad` | `rad2sm`

sm2rad

Purpose

Convert distance from statute miles to radians

Syntax

```
rad = sm2rad(sm)
rad = sm2rad(sm,radius)
rad = sm2rad(sm,sphere)
```

Description

`rad = sm2rad(sm)` converts distances from statute miles to radians as measured along a great circle on a sphere with a radius of 6371 km, the mean radius of the Earth.

`rad = sm2rad(sm,radius)` converts distances from statue miles to radians as measured along a great circle on a sphere having the specified radius. `radius` must be in units of statute miles.

`rad = sm2rad(sm,sphere)` converts distances from statute miles to radians, as measured along a great circle on a sphere approximating an object in the Solar System. *`sphere`* may be one of the following strings: `'sun'`, `'moon'`, `'mercury'`, `'venus'`, `'earth'`, `'mars'`, `'jupiter'`, `'saturn'`, `'uranus'`, `'neptune'`, or `'pluto'`, and is case-insensitive.

See Also

`degtorad` | `radtodeg` | `rad2km` | `km2deg` | `km2nm` | `km2sm` | `rad2nm` | `nm2deg` | `nm2km` | `nm2sm` | `rad2sm` | `sm2deg` | `sm2km` | `sm2nm`

Purpose

Remove discontinuities in longitude data

Note The `smoothlong` function is obsolete and has been replaced by `unwrapMultipart`, which requires input to be in radians. When working in degrees, use `radtodeg(unwrapMultipart(degtorad(lon)))`.

Syntax

```
ang = smoothlong(angin)
ang = smoothlong(angin,angleunits)
```

Description

`ang = smoothlong(angin)` removes discontinuities in longitude data. The resulting angles can cover more than one revolution.

`ang = smoothlong(angin,angleunits)` uses the units defined by the input string *`angleunits`*. If omitted, default units of `'degrees'` are assumed. Valid *`angleunits`* are:

- `'degrees'` — decimal degrees
- `'radians'`

See Also

`unwrapMultipart`

spcread

Purpose

Read columns of data from ASCII text file

Syntax

```
mat = spcread
mat = spcread(filename)
mat = spcread(cols)
```

Description

`mat = spcread` reads an ASCII file of space-delimited data in two columns and returns the data in a matrix, `mat`. The file is selected by dialog box.

`mat = spcread(filename)` specifies the file from which to read by its name, given as the string *`filename`*.

`mat = spcread(cols)` specifies the number of columns of space-delimited data in the file with the integer `cols`. The default value of `cols` is 2.

Tips

The `spcread` function is similar to the standard MATLAB function `dlmread`. `spcread`, however, is much faster at reading large data sets of the type common for geographic purposes.

See Also

`nanclip`

Purpose

Construct sparse regular data grid of 0s

Syntax

```
[Z,refvec] = spzerom(latlim,lonlim,scale)
```

Description

`[Z,refvec] = spzerom(latlim,lonlim,scale)` returns a sparse regular data grid consisting entirely of `0`s and a three-element referencing vector for the returned `Z`. The two-element vectors `latlim` and `lonlim` define the latitude and longitude limits of the geographic region. They should be of the form `[south north]` and `[west east]`, respectively. The scalar `scale` specifies the number of rows and columns per degree of latitude and longitude.

Examples

```
[Z,refvec] = spzerom([46,51],[-79,-75],1)

Z =
   All zero sparse: 5-by-4
refvec =
     1    51   -79
```

See Also

`limitm` | `nanm` | `onem` | `sizem` | `zerom`

stdist

Purpose

Standard distance for geographic points

Syntax

```
dist = stdist(lat,lon)
dist = stdist(lat,lon,units)
dist = stdist(lat,lon,ellipsoid)
dist = stdist(lat,lon,ellipsoid,units,method)
```

Description

`dist = stdist(lat,lon)` computes the average standard distance for geographic data. This function assumes that the data is distributed on a sphere. In contrast, `std` assumes that the data is distributed on a Cartesian plane. The result is a single value based on the great-circle distance of the data points from their geographic mean point. When `lat` and `lon` are vectors, a single distance is returned. When `lat` and `lon` are matrices, a row vector of distances is given, providing the distances for each column of `lat` and `lon`. N-dimensional arrays are not allowed. Distances are returned in degrees of angle units.

`dist = stdist(lat,lon,units)` indicates the angular units of the data. When the standard angle string *`units`* is omitted, `'degrees'` is assumed. Output measurements are in terms of these *`units`* (as arc length distance).

`dist = stdist(lat,lon,ellipsoid)` specifies the shape of the Earth to be used with `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The default is a unit sphere. Output measurements are in terms of the distance units of the semimajor axis of the `ellipsoid`.

`dist = stdist(lat,lon,ellipsoid,units,method)` specifies the method of calculating the standard distance of the data. The default, `'linear'`, is simply the average great circle distance of the data points from the centroid. Using `'quadratic'` results in the square root of the average of the squared distances, and `'cubic'` results in the cube root of the average of the cubed distances.

Background

The function `stdm` provides independent standard deviations in latitude and longitude of data points. `stdist` provides a means of examining

data scatter that does not separate these components. The result is a *standard distance*, which can be interpreted as a measure of the scatter in the great circle distance of the data points from the centroid as returned by `meanm`.

The output distance can be thought of as the radius of a circle centered on the geographic mean position, which gives a measure of the spread of the data.

Examples

Create latitude and longitude lists using the `worldcities` data set and obtain standard distance deviation for group (compare with the example for `stdm`):

```
cities = shaperead('worldcities.shp', 'UseGeoCoords', true);
Paris = strcmp('Paris',{cities(:).Name});
London = strcmp('London',{cities(:).Name});
Rome = strcmp('Rome',{cities(:).Name});
Madrid = strcmp('Madrid',{cities(:).Name});
Berlin = strcmp('Berlin',{cities(:).Name});
Athens = strcmp('Athens',{cities(:).Name});
lat = [cities(Paris).Lat cities(London).Lat...
       cities(Rome).Lat cities(Madrid).Lat...
       cities(Berlin).Lat cities(Athens).Lat]
lon = [cities(Paris).Lon cities(London).Lon...
       cities(Rome).Lon cities(Madrid).Lon...
       cities(Berlin).Lon cities(Athens).Lon]

dist = stdist(lat,lon)

lat =
   48.8708   51.5188   41.9260   40.4312   52.4257   38.0164
lon =
    2.4131   -0.1300   12.4951   -3.6788   13.0802   23.5183
dist =
    8.1827
```

See Also

`meanm` | `stdm`

stdm

Purpose

Standard deviation for geographic points

Syntax

```
[latdev,londev] = stdm(lat,lon)
[latdev,londev] = stdm(lat,lon,ellipsoid)
[latdev,londev] = stdm(lat,lon,units)
```

Description

`[latdev,londev] = stdm(lat,lon)` returns row vectors of the latitude and longitude geographic standard deviations for the data points specified by the columns of `lat` and `lon`.

`[latdev,londev] = stdm(lat,lon,ellipsoid)` specifies the shape of the Earth to be used by the `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The default ellipsoid is a unit sphere. Output measurements are in terms of the distance units of the `ellipsoid` vector.

`[latdev,londev] = stdm(lat,lon,units)` indicates the angular units of the data. When the standard angle string *`units`* is omitted, `'degrees'` is assumed. Output measurements are in terms of these *`units`* (as arc length distance).

If a single output argument is used, then `geodevs = [latdev longdev]`. This is particularly useful if the original `lat` and `lon` inputs are column vectors.

Background

Determining the deviations of geographic data in latitude and longitude is more complicated than simple sum-of-squares deviations from the data averages. For latitude deviation, a straightforward angular standard deviation calculation is performed from the *geographic mean* as calculated by `meanm`. For longitudes, a similar calculation is performed based on data *departure* rather than on angular deviation. See "Geographic Statistics" in the *Mapping Toolbox User's Guide*.

Examples

Create latitude and longitude lists using the `worldcities` data set and obtain standard distance deviation for group (compare with the example for `stdist`):

```
cities = shaperead('worldcities.shp', 'UseGeoCoords', true);
Paris = strcmp('Paris',{cities(:).Name});
London = strcmp('London',{cities(:).Name});
Rome = strcmp('Rome',{cities(:).Name});
Madrid = strcmp('Madrid',{cities(:).Name});
Berlin = strcmp('Berlin',{cities(:).Name});
Athens = strcmp('Athens',{cities(:).Name});
lat = [cities(Paris).Lat cities(London).Lat...
       cities(Rome).Lat cities(Madrid).Lat...
       cities(Berlin).Lat cities(Athens).Lat]
lon = [cities(Paris).Lon cities(London).Lon...
       cities(Rome).Lon cities(Madrid).Lon...
       cities(Berlin).Lon cities(Athens).Lon]
[latstd,lonstd]=stdm(lat,lon)

lat =
   48.8708   51.5188   41.9260   40.4312   52.4257   38.0164
lon =
    2.4131   -0.1300   12.4951   -3.6788   13.0802   23.5183
latstd =
    2.7640
lonstd =
   68.7772
```

See Also

departure | filterm | hista | histr | meanm | stdist

Purpose

Project stem plot map on map axes

Syntax

```
h = stem3m(lat,lon,z)
h = stem3m(lat,lon,z,LineType)
h = stem3m(lat,lon,z,PropertyName,PropertyValue,...)
```

Description

`h = stem3m(lat,lon,z)` displays a stem plot on the current map axes. Stems are located at the points (`lat`,`lon`) and extend from an altitude of 0 to the values of `z`. The coordinate inputs should be in the same `AngleUnits` as the map axes. It is important to note that the selection of *z*-values will greatly affect the 3-D look of the plot. Regardless of `AngleUnits`, the *x* and *y* limits of the map axes are at most -π to +π and -π/2 to +π/2, respectively. This means that for most purposes, appropriate `z` values would be on the order of 1 to 3, not 10 to 30. The axes `DataAspectRatio` property can be used to adjust the appearance of the graphic. The handles of the displayed stem lines can be returned in `h`.

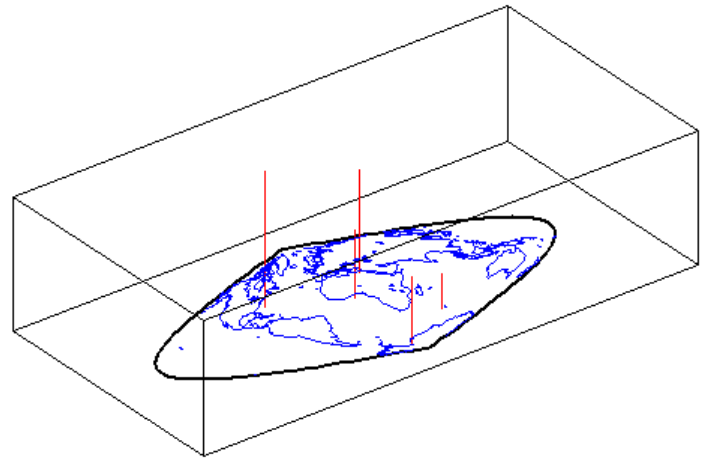
`h = stem3m(lat,lon,z,LineType)` allows the style of the stem plot's lines to be specified with any string *`LineType`* recognized by the MATLAB `line` function.

`h = stem3m(lat,lon,z,PropertyName,PropertyValue,...)` allows any property/value pair recognized by the MATLAB `line` function to be specified for the stems.

A stem plot displays data as lines extending normal to the *xy*-plane, in this case, on a map.

Examples

```
load coast
axesm sinusoid; view(3)
h = framem; set(h,'zdata',zeros(size(lat)))
plotm(lat,long)
ptlat = [0 30 30 -50 -78]';
ptlon = [0 30 -70 65 -35]';
ptz = [1 1.5 2 .5 1]';
stem3m(ptlat,ptlon,ptz,'r-')
```



See Also

scatterm

str2angle

Purpose

Convert strings to angles in degrees

Syntax

```
angles = str2angle(strings)
```

Description

`angles = str2angle(strings)` converts strings containing latitudes and/or longitudes, expressed in one of four different formats of degree-minutes-seconds, to numeric angles in units of degrees.

Format Description	Example
Degree Symbol, Single/Double Quotes	`'123 30''00"W'`
'd', 'm', 's' Separators	`'123d30m00sW'`
Minus Signs as Separators	`'123-30-00W'`
"Packed DMS"	`'1233000W'`

Input must conform closely to the examples provided; in particular, the seconds field must be included, even if it is not significant. Except in Packed DMS format, the seconds field can contain a fractional component. Sign characters are not supported; terminate each string with `'N'` for positive latitude, `'S'` for negative latitude, `'E'` for positive longitude, or `'W'` for negative longitude. `strings` is string or a cell array of strings. For backward compatibility, `strings` can also be a character matrix. If more than one angle is represented, `strings` can either contain homogeneous or heterogeneous formatting (see example). `angles` is a column vector of class double.

Examples

```
strs = {'23 30''00"N', '23-30-00S', '123d30m00sE', '1233000W'}

strs =
    '23 30'00"N'    '23-30-00S'    '123d30m00sE'    '1233000W'

str2angle(strs)

ans =
         23.5
```

```
   -23.5
   123.5
  -123.5
```

See Also

angl2str

surfacem

Purpose

Project and add geolocated data grid to current map axes

Syntax

```
surfacem(lat,lon,Z)
surfacem(latlim,lonlim,Z)
surfacem(lat,lon,Z,alt)
surfacem(...,prop1,val1,prop2,val2,...)
h = surfacem(...)
```

Description

`surfacem(lat,lon,Z)` constructs a surface to represent the data grid `Z` in the current map axes. The surface lies flat in the horizontal plane with its `CData` property set to `Z`. The vectors or 2-D arrays `lat` and `lon` define the latitude-longitude graticule mesh on which `Z` is displayed. For a complete description of the various forms that `lat` and `lon` can take, see `surfm`.

`surfacem(latlim,lonlim,Z)` defines the graticule using the latitude and longitude limits `latlim` and `lonlim`. These limits should match the geographic extent of the data grid `Z`. The two-element vector `latlim` has the form:

```
[southern_limit northern_limit]
```

Likewise, `lonlim` has the form:

```
[western_limit eastern_limit]
```

A latitude-longitude graticule of size 50-by-100 is constructed. The surface `FaceColor` property is `'texturemap'`, except when `Z` is precisely 50-by-100, in which case it is `'flat'`.

`surfacem(lat,lon,Z,alt)` sets the `ZData` property of the surface to `'alt'`, resulting in a 3-D surface. `Lat` and `lon` must result in a graticule mesh that matches `alt` in size. `CData` is set to `Z`. `Facecolor` is `'texturemap'`, unless `Z` matches `alt` in size, in which case it is `'flat'`.

`surfacem(...,prop1,val1,prop2,val2,...)` applies additional MATLAB graphics properties to the surface via property/value pairs. You can specify any property accepted by the `surface` function, except `XData`, `YData`, and `ZData`.

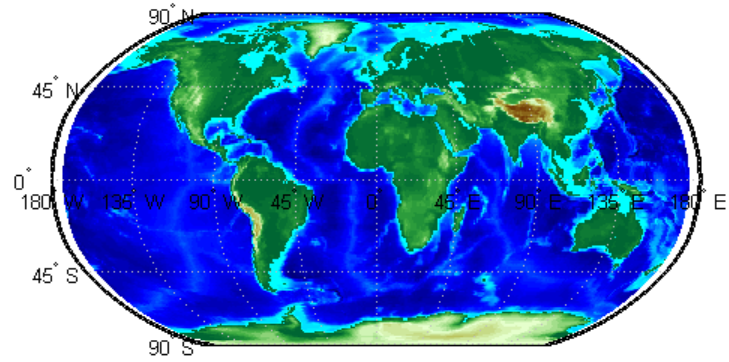
`h = surfacem(...)` returns a handle to the surface object.

Note Unlike `meshm` and `surfm`, `surfacem` always adds a surface to the current axes, regardless of hold state.

Examples

Construct a surface to represent the data grid `topo`.

```
  figure('Color','white')
load topo
  latlim = [-90  90];
  lonlim = [  0 360];
  gratsize = 1 + [diff(latlim), diff(wrapTo360(lonlim))]/6;
  [lat, lon] = meshgrat(latlim, lonlim, gratsize);
  worldmap world
  surfacem(lat, lon, topo)
  demcmap(topo)
```



See Also

`geoshow` | `meshm` | `pcolorm` | `surfm`

surflm

Purpose

3-D shaded surface with lighting on map axes

Syntax

```
surflm(lat,lon,Z)
surflm(latlim,lonlim,Z)
surflm(...,s)
surflm(...,s,k)
h = surflm(...)
```

Description

`surflm(lat,lon,Z)` and `surflm(latlim,lonlim,Z)` are the same as `surfm(...)` except that they highlight the surface with a light source. The default light source (45 degrees counterclockwise from the current view) and reflectance constants are the same as in `surfl`.

`surflm(...,s)` and `surflm(...,s,k)` use a light source vector, `s`, and a vector of reflectance constants, `k`. For more information on `s` and `k`, see the help for `surfl`.

`h = surflm(...)` returns a handle to the surface object.

Tips

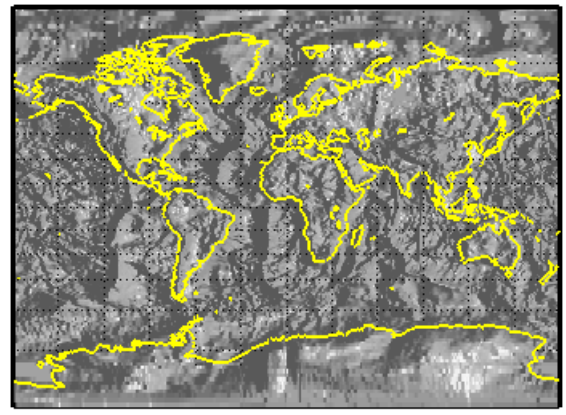
`surflm` is like `surfm`, except that it shades the monochrome map surface with a light source, and the only allowed graticule is the size of the data matrix.

Examples

Project a 3-D shaded surface with lighting on the current map axes. Note that in the following example, the graticule is the size of `topo` (180 x 360) and is rendered in 3-D, so it might take a while. It is also memory intensive:

```
figure('Color','white')
load topo
axesm miller
axis off; framem on; gridm on;
[lat,lon] = meshgrat(topo,topolegend);
surflm(lat,lon,topo)
colormap(gray)
coast = load('coast');
plotm(coast.lat,coast.long,max(topo(:)),...
```

```
'LineWidth',1.5,'Color','yellow')
```



See Also

surfm

surflsrm

Purpose

3-D lighted shaded relief of geolocated data grid

Syntax

```
surflsrm(lat,long,Z)
surflsrm(lat,long,Z,[azim elev])
surflsrm(lat,long,Z,[azim elev],cmap)
surflsrm(lat,long,Z,[azim elev],cmap,clim)
h = surflsrm(...)
```

Description

`surflsrm(lat,long,Z)` displays the geolocated data grid, colored according to elevation and surface slopes. The current axes must have a valid map projection definition.

`surflsrm(lat,long,Z,[azim elev])` displays the geolocated data grid with the light coming from the specified azimuth and elevation. Lighting is applied before the data is projected. Angles are in degrees, with the azimuth measured clockwise from North, and elevation up from the zero plane of the surface. By default, the direction of the light source is east (90º azimuth) at an elevation of 45º.

`surflsrm(lat,long,Z,[azim elev],cmap)` displays the geolocated data grid using the provided colormap. The number of grayscales is chosen to keep the size of the shaded colormap below 256. By default, the colormap is constructed from 16 colors and 16 grays. If the vector of azimuth and elevation is empty, the default locations are used.

`surflsrm(lat,long,Z,[azim elev],cmap,clim)` uses the provided color axis limits, which are, by default, automatically computed from the data.

`h = surflsrm(...)` returns the handle to the surface drawn.

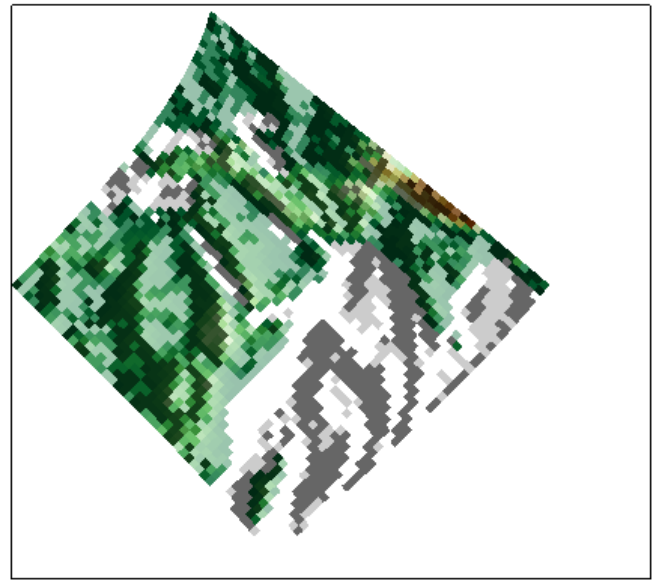
Tips

This function effectively multiplies two colormaps, one with color based on elevation, the other with a grayscale based on the slope of the surface, to create a new colormap. This produces an effect similar to using a light on a surface, but with all of the visible colors actually in the colormap. Lighting calculations are performed on the unprojected data.

Examples

Create a new colormap using `demcmap` with white colors for the sea and default colors for land. Use this colormap for the lighted shaded relief map of the Middle East region:

```
load mapmtx
[cmap,clim] = demcmap(map1,[],[1 1 1],[]);
axesm loximuth
surflsrm(lt1,lg1,map1,[],cmap,clim)
```



See Also

`meshlsrm` | `meshm` | `pcolorm` | `shaderel` | `surfacem` | `surflm` | `surfm`

surfm

Purpose

Project geolocated data grid on map axes

Syntax

```
surfm(lat,lon,Z)
surfm(latlim,lonlim,Z)
surfm(lat,lon,Z,alt)
surfm(...,prop1,val1,prop2,val2,...)
h = surfm(...)
```

Description

`surfm(lat,lon,Z)` constructs a surface to represent the data grid `Z` in the current map axes. The surface lies flat in the horizontal plane with its `CData` property set to `Z`. The 2-D arrays or vectors `lat` and `lon` define the latitude-longitude graticule mesh on which `Z` is displayed. The sizes and shapes of `lat` and `lon` affect their interpretation, and also determine whether the default `FaceColor` property of the surface is `'flat'` or `'texturemap'`. There are three options:

- 2-D arrays (matrices) having the same size as `Z`. `Lat` and `lon` are treated as geolocation arrays specifying the precise location of each vertex. `FaceColor` is `'flat'`.
- 2-D arrays having a different size than `Z`. The arrays `lat` and `lon` define a graticule mesh that might be either larger or smaller than `Z`. `Lat` and `lon` must match each other in size. `FaceColor` is `'texturemap'`.
- Vectors having more than two elements. The elements of `lat` and `lon` are repeated to form a graticule mesh with size equal to `numel(lat)-by-numel(lon)`. `FaceColor` is `'flat'` if the graticule mesh matches `Z` in size. Otherwise, `FaceColor` is `'texturemap'`.

`surfm` clears the current map if the hold state is `'off'`.

`surfm(latlim,lonlim,Z)` defines the graticule using the latitude and longitude limits `latlim` and `lonlim`, which should match the geographic extent of the data grid `Z`. `Latlim` is a two-element vector of the form:

```
[southern_limit northern_limit]
```

Likewise `lonlim` has the form:

```
[western_limit eastern_limit]
```

A latitude-longitude graticule is constructed to match `Z` in size. The surface `FaceColor` property is `'flat'` by default.

`surfm(lat,lon,Z,alt)` sets the `ZData` property of the surface to `'alt'`, resulting in a 3-D surface. `lat` and `lon` must result in a graticule mesh that matches `alt` in size. `CData` is set to `Z`. The `FaceColor` property is `'texturemap'`, unless `Z` matches `alt` in size, in which case it is `'flat'`.

`surfm(...,prop1,val1,prop2,val2,...)` applies additional MATLAB graphics properties to the surface via property/value pairs. You can specify any property accepted by the `surface` function except `XData`, `YData`, and `ZData`.

`h = surfm(...)` returns a handle to the surface object.

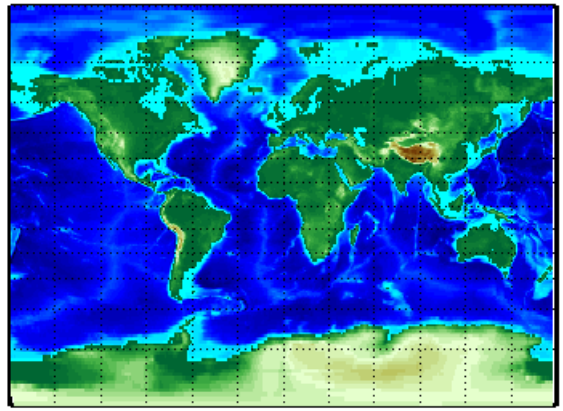
Tips

This function warps a data grid to a graticule mesh, which is projected according to the map axes property `MapProjection`. The fineness, or resolution, of this grid determines the quality of the projection and the speed of plotting it. There is no hard and fast rule for sufficient graticule resolution, but in general, cylindrical projections need very few graticule points in the longitudinal direction, while complex curve-generating projections require more.

Examples

Construct a surface to represent the data grid `topo`.

```
figure('Color','white')
load topo
axesm miller
axis off; framem on; gridm on;
[lat,lon] = meshgrat(topo,topolegend,[90 180]);
surfm(lat,lon,topo)
demcmap(topo)
```



See Also

geoshow | meshgrat | meshm | pcolorm | surfacem

Purpose

Project point markers with variable size

Syntax

```
symbolm(lat,lon,z,'MarkerType')
symbolm(lat,lon,z,'MarkerType','PropertyName',PropertyValue,
   ...)
h = symbolm(...)
```

Description

`symbolm(lat,lon,z,'MarkerType')` constructs a thematic map where the symbol size of each data point (`lat, lon`) is proportional to it weighting factor (`z`). The point corresponding to `min(z)` is drawn at the default marker size, and all other points are plotted with proportionally larger markers. The `MarkerType` string is a LineSpec string specifying a marker and optionally a color.

`symbolm(lat,lon,z,'MarkerType','PropertyName',PropertyValue,...)` applies the line properties to all the symbols drawn.

`h = symbolm(...)` returns a vector of handles to the projected symbols. Each symbol is projected as an individual line object.

See also

`stem3m`, `plotm`, `plot`

tagm

Purpose

Set `Tag` property of map graphics object

Syntax

```
tagm(hndl,tagstr)
```

Description

`tagm(hndl,tagstr)` sets the `Tag` property of each object designated in the vector of handles `hndl` to the associated string (row) of the matrix of strings `tagstr`.

This property is recognized by the `namem` and `handlem` functions.

Examples

Normally, a plotted line has a name of `'line'`:

```
axesm miller
lats = [3 2 1 1 2 3]; longs = [7 8 9 7 8 9];
h=plotm(lats,longs);

untagged = namem(h)
untagged =
line
```

The `tagm` function can rename it:

```
tagm(h,'testpath');
tagged = namem(h)
tagged =
testpath
```

See Also

`clma` | `clmo` | `handlem` | `hidem` | `namem` | `showm`

Purpose

Read 5-minute global terrain elevations from TerrainBase

Syntax

```
[Z,refvec] = tbase(scalefactor)
[Z,refvec] = tbase(scalefactor,latlim,lonlim)
```

Description

`[Z,refvec] = tbase(scalefactor)` reads the data for the entire world, reducing the resolution of the data by the specified scale factor. The result is returned as a regular data grid and an associated three-element referencing vector.

`[Z,refvec] = tbase(scalefactor,latlim,lonlim)` reads the data for the part of the world within the latitude and longitude limits. The limits must be two-element vectors in units of degrees.

Background

TerrainBase is a global model of terrain and bathymetry on a regular 5-minute grid (approximately 10 km resolution). It is a compilation of the public domain data from almost 20 different sources, including the DCW-DEM and ETOPO5. The data set was created by the National Geophysical Data Center and World Data Center-A for Solid Earth Geophysics in Boulder, Colorado.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: http://www.mathworks.com/help/map/finding-geospatial-data.html

---

Examples

Read every 10th point in the data set:

```
[Z,refvec] = tbase(10);
whos
```

```
  Name              Size          Bytes  Class

  Z               216x432        746496  double array
  refvec            1x3              24  double array
```

```
limitm(Z,refvec)

ans =
   -90    90     0   360
```

Read data for Korea and Japan at the full resolution:

```
scalefactor = 1; latlim = [30 45]; lonlim = [115 145];
[Z,refvec] = tbase(scalefactor,latlim,lonlim);
whos datagrid

  Name        Size          Bytes  Class

  Z         180x360        518400  double array
```

See Also

gtopo30 | etopo | usgsdem

Purpose

Project text annotation on map axes

Syntax

```
textm(lat,lon,string)
textm(lat,lon,z,string)
textm(lat,lon,z,string,PropertyName,PropertyValue,...)
h = textm(...)
```

Description

`textm(lat,lon,string)` projects the text in `string` onto the current map axes at the locations specified by the `lat` and `lon`. The units of `lat` and `lon` must match the `'angleunits'` property of the map axes. If `lat` and `lon` contain multiple elements, `textm` places a text object at each location. In this case `string` may be a cell array of strings with the same number of elements as `lat` and `lon`. (For backward compatibility, `string` may also be a 2-D character array such that size`(string,1)` matches `numel(lat)`).

`textm(lat,lon,z,string)` draws the text at the altitude(s) specified in `z`, which must be the same size as `lat` and `lon`. The default altitude is 0.

`textm(lat,lon,z,string,PropertyName,PropertyValue,...)` sets the text object properties. All properties supported by the MATLAB `text` function are supported by `textm`.

`h = textm(...)` returns the handles to the text objects drawn.

Tips

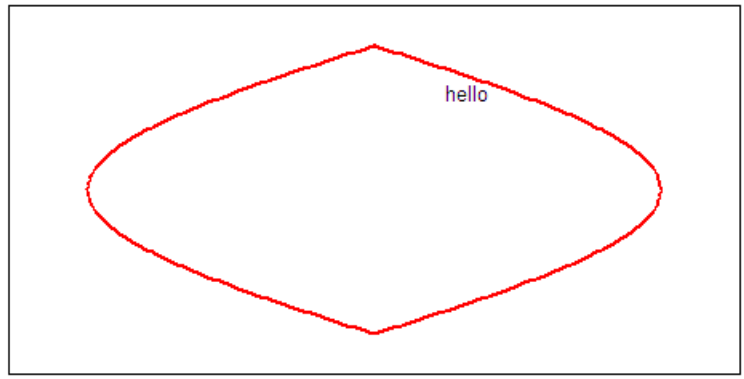
You may be working with scalar `lat` and `lon` data or vector `lat` and `lon` data. If you are in scalar mode and you enter a cell array of strings, you will get a text object with a multiline string. Also note that vertical slash characters, rather than producing multiline strings, will yield a single line string containing vertical slashes. On the other hand, if `lat` and `lon` are nonscalar, then the size of the cell array input must match their size exactly.

Examples

The feature of `textm` that distinguishes it from the standard MATLAB text function is that the `text` object is projected appropriately. Type the following:

```
axesm sinusoid
```

```
framem('FEdgeColor','red')
textm(60,90,'hello')
```




```
figure; axesm miller
framem('FEdgeColor','red')
textm(60,90,'hello')
```

The string `'hello'` is placed at the same geographic point, but it appears to have moved relative to the axes because of the different projections. If you change the projection using the `setm` function, the text moves as necessary. Use `text` to fix text objects in the axes independent of projection.

See Also

`axesm` | `text`

tgrline

Purpose

Read TIGER/Line data

Note `tgrline` will be removed in a future version. More recent TIGER/Line data sets are available in shapefile format and can be imported using `shaperead`.

Syntax

```
[CL,PR,SR,RR,H,AL,PL] = tgrline(filename)
[CL,PR,SR,RR,H,AL,PL] = tgrline(filename,year)
[CL,PR,SR,RR,H,AL,PL] = tgrline(filename,year,countyname)
```

Description

`[CL,PR,SR,RR,H,AL,PL] = tgrline(filename)` reads a set of 1994 TIGER/Line files which share the same filename, but different extensions. The results are returned in a set of Mapping Toolbox display structures tagged with feature names and containing:

- county boundaries (CL)
- primary roads (PR)
- secondary roads (SR)
- railroads (RR)
- hydrography (H)
- area landmarks (AL)
- point landmarks (PL)

`[CL,PR,SR,RR,H,AL,PL] = tgrline(filename,year)` reads the TIGER line files in the format from that year. The layout of TIGER/Line files is updated periodically and filename extensions may change from year to year. Valid years are 1990, 1992, 1994, 1995, 1999, 2000, 2002, 2003, and 2004.

`[CL,PR,SR,RR,H,AL,PL] = tgrline(filename,year,countyname)` uses the string `countyname` to tag the county data.

Background

The United States Census Bureau distributes TIGER/Line data over the Internet and via CD-ROM or DVD.

TIGER/Line files contain vector map data used to support mapping for the U.S. Census Bureau. TIGER is an acronym for Topographically Integrated Geographic Encoding and Referencing. These files contain data for political boundaries, including states, counties, Indian reservations, and census tracts, as well as roads, railroads, hydrography, and landmarks. In addition to the geographically referenced information, the files also contain data to determine the address of an object. The data covers the United States of America and its territories or administrative units: Puerto Rico, the Virgin Islands of the United States, American Samoa, Guam, the Commonwealth of the Northern Marianna Islands, the Republic of Palau, the other Pacific entities that were part of the Trust Territory of the Pacific Islands (the Republic of the Marshall Islands and the Federated States of Micronesia), and the Midway Islands. The most common application of this data is to commercial CD-ROM road atlases.

TIGER/Line is a registered trademark of the United States Census Bureau.

Tips

This function reads only a subset of the data in the TIGER/Line files. For example, the function does not return local roads, zip codes, or census tract numbers.

Data are returned as Mapping Toolbox display structures, which you can then update to geographic data structures. For information about display structure format, see “Version 1 Display Structures” on page 3-177 in the reference page for `displaym`. The `updategeostruct` function performs such conversions.

Examples

Read from the data for Washington, D.C.:

```
[CL,PR,SR,RR,H,AL,PL] = tgrline('TGR11001',1994,'Wash,DC');
```

See Also

`shaperead` | `updategeostruct`

tightmap

Purpose

Remove white space around map

Syntax

```
tightmap
```

Description

`tightmap` sets the axis limits to be tight around the map in the current axes. This eliminates or reduces the white border between the map frame and the axes box. Use `axis auto` to undo `tightmap`.

Tips

The axis limits are fixed. If a change in the projection parameters changes the size or position of the map display within the projected coordinate system, execute `tightmap` again. Also note that `tightmap` needs to be re-applied following any call to `setm` that causes projected map objects to be re-projected.

The `tightmap` function performs no action on a `'globe'` map axes.

Examples

Display a map of Africa. Notice the white space between the map frame and the edge of the axes box.

```
axesm('miller','maplatlim',[-40 40],'maplonlim',[-20 60])
framem; gridm; mlabel; plabel
load coast
plotm(lat, long)
```

Now use `tightmap` to reduce the wasted space:

```
tightmap
```

See Also

`panzoom` | `zoom` | `paperscale` | `axesscale` | `previewmap`

Purpose

Time zone based on longitude

Syntax

```
[zd,zltr,zone] = timezone(long)
[zd,zltr,zone] = timezone(long,units)
```

Description

`[zd,zltr,zone] = timezone(long)` returns an integer zone description, `zd`, an alphabetical string zone indicator, `zltr`, and a string, `zone`, with the complete zone description and alphabetical zone indicator corresponding to the input longitude `long`.

`[zd,zltr,zone] = timezone(long,units)` specifies the angular units with a standard angle *`units`* string. The default value is `'degrees'`. Valid *`units`* are:

- `'degrees'` — decimal degrees
- `'radians'`

Examples

Given that it is locally 1330 (1:30 p.m.) at a longitude of 75ºW, determine GMT:

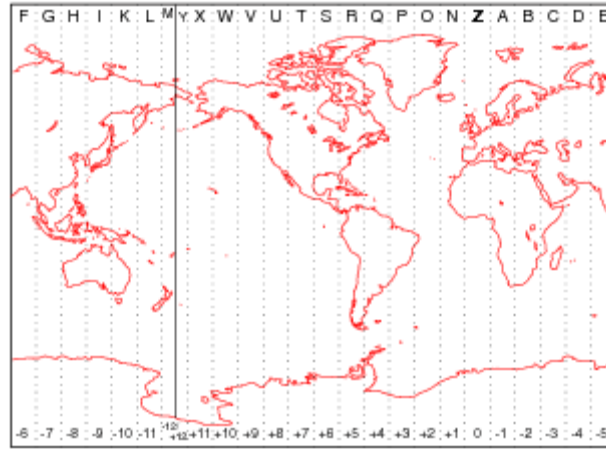
```
[zd,zltr,zone] = timezone(-75,'degrees')

zd =
     5
zltr =
R
zone =
+5 R
```

Greenwich Mean Time (GMT) is 1330 plus five hours, or 1830 (6:30 p.m.).

Background

Time is determined by the position of the Sun relative to the prime meridian, the zero longitude line running through Greenwich, England. When this meridian lies directly below the Sun, it is noon GMT. For local times elsewhere, the Earth is divided into 15º longitude bands, each centered on a central meridian. When a central meridian lies

directly below the Sun, Local Mean Time (LMT) in that zone is noon. The zone description is an integer that when added to LMT gives GMT. For notational convenience, each zone is also given an alphabetical indicator. The indicator at Greenwich is *Z*, so GMT is often called *ZULU time*.



Note that there are actually 25 time zones, because the zone centered on the International Date Line (180º E/W) is split into two: "+12 Y" and "-12 M."

Limitations

National and local governments set their own time zone boundaries for political or geographic convenience. The `timezone` function does not account for statutory deviations from the meridian-based system.

Purpose

Project Tissot indicatrices on map axes

Syntax

```
h = tissot
h = tissot(spec)
h = tissot(spec,linestyle)
h = tissot(linestyle)
h = tissot(spec,PropertyName,PropertyValue,...)
h = tissot(linestyle,PropertyName,PropertyValue,...)
```

Description

`h = tissot` plots the default Tissot diagram, as described above, on the current map axes and returns handles for the displayed indicatrices.

`h = tissot(spec)` allows you to specify plotting parameters of the displayed Tissot diagram as described above.

`h = tissot(spec,linestyle)` and `h = tissot(linestyle)` specify any *`linestyle`* string recognized by the standard MATLAB `line` function to set the line style of the Tissot indicatrices.

`h = tissot(spec,PropertyName,PropertyValue,...)` and `h = tissot(linestyle,PropertyName,PropertyValue,...)` allow the specification of any property and value recognized by the `line` function.

Background

Tissot indicatrices are plotting symbols that are useful for understanding the various distortions of a given map projection. The indicatrices are circles of identical true radius on the Earth's surface. When plotted on a map projection, they indicate whether the projection has certain features. If the plotted indicatrices all enclose the same area, the projection is equal area (for example, a Sinusoidal projection would have this feature). If they all remain circular, then conformality is indicated (a Mercator projection has this property). Distortions in meridianal or parallel distance are exhibited by flattened or stretched indicatrices. Many projections will show very even, circular indicatrices in some regions, often near the center, and wildly distorted indicatrices in others, such as near the edges. The Tissot diagram is therefore very useful in analyzing the appropriateness of a projection to a given purpose or region.

The general layout of the Tissot diagram is defined by the specification vector `spec`.

```
spec = [Radius]
spec = [Latint,Longint]
spec = [Latint,Longint,Radius]
spec = [Latint,Longint,Radius,Points]
```

`Radius` is the small circle radius of each indicatrix circle. If entered, it should be in the same units as the map axes `Geoid`. The default radius is 1/10th the radius of the sphere.

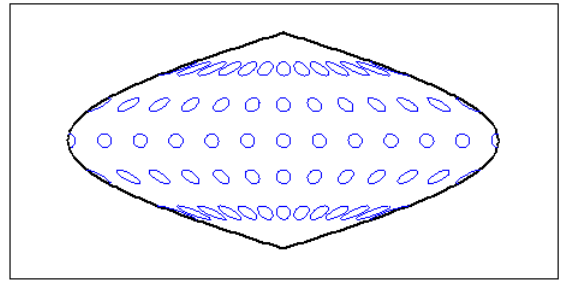
`Latint` is the latitude interval between indicatrix circle centers. If entered it should be in the map axes `AngleUnits`. The default value is one circle every 30º of latitude (that is, 0º, +/-30º, etc.).

`Longint` is the longitude interval between indicatrix circle centers. If entered it should be in the map axes `AngleUnits`. The default value is one circle every 30º of latitude (that is, 0º, +/-30º, etc.).

`Points` is the number of plotting points per circle. The default is 100 points.

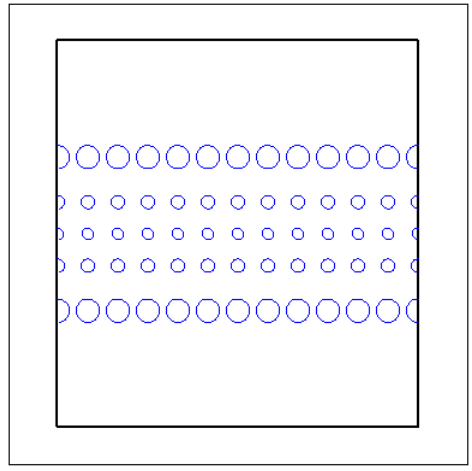
Examples

```
axesm sinusoid; framem
tissot
```



The Sinusoidal projection is equal area.

```
setm(gca,'MapProjection','Mercator')
```



The Mercator projection is conformal.

See Also

`mdistort` | `distortcalc`

How To

- “Supported Map Projections”

toDegrees

Purpose

Convert angles to degrees

Syntax

```
[angle1InDegrees, angle2InDegrees,
   ...] = toDegrees(fromUnits, angle1, angle2, ...)
```

Description

`[angle1InDegrees, angle2InDegrees, ...] = toDegrees(fromUnits, angle1, angle2, ...)` converts `angle1, angle2, ...` to degrees from the specified angle units. *`fromUnits`* can be either `'degrees'` or `'radians'` and may be abbreviated. The inputs `angle1, angle2, ...` and their corresponding outputs are numeric arrays of various sizes, with `size(angleNinDegrees)` matching `size(angleN)`.

See Also

`fromDegrees` | `fromRadians` | `radtodeg` | `toRadians`

Purpose

Convert angles to radians

Syntax

```
[angle1InRadians, angle2InRadians,
   ...] = toRadians(fromUnits, angle1, angle2, ...)
```

Description

`[angle1InRadians, angle2InRadians, ...] = toRadians(fromUnits, angle1, angle2, ...)` converts `angle1, angle2, ...` to radians from the specified angle units. *`fromUnits`* can be either `'degrees'` or `'radians'` and may be abbreviated. The inputs `angle1, angle2, ...` and their corresponding outputs are numeric arrays of various sizes, with `size(angleNinRadians)` matching `size(angleN)`.

See Also

`degtorad` | `fromDegrees` | `fromRadians` | `toDegrees`

track

Purpose

Track segments to connect navigational waypoints

Syntax

```
[lattrk,lontrk] = track(waypts)
[lattrk,lontrk] = track(waypts,units)
[lattrk,lontrk] = track(lat,lon)
[lattrk,lontrk] = track(lat,lon,ellipsoid)
[lattrk,lontrk] = track(lat,lon,ellipsoid,units,npts)
[lattrk,lontrk] = track(method,lat,...)
trkpts = track(lat,lon...)
```

Description

`[lattrk,lontrk] = track(waypts)` returns points in `lattrk` and `lontrk` along a track between the waypoints provided in navigational track format in the two-column matrix `waypts`. The outputs are column vectors in which successive segments are delineated with `NaN`s.

`[lattrk,lontrk] = track(waypts,units)` specifies the units of the inputs and outputs, where *`units`* is any valid angle unit string. The default is `'degrees'`.

`[lattrk,lontrk] = track(lat,lon)` allows the user to input the waypoints in two vectors, `lat` and `lon`.

`[lattrk,lontrk] = track(lat,lon,ellipsoid)` specifies the shape of the Earth using `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. The default ellipsoid is a unit sphere

`[lattrk,lontrk] = track(lat,lon,ellipsoid,units,npts)` establishes how many intermediate points are to be calculated for every track segment. By default, `npts` is 30.

`[lattrk,lontrk] = track(method,lat,...)` establishes the logic to be used to determine the intermediate points along the track between waypoints. Because this is a navigationally motivated function, the default method is `'rh'`, which results in rhumb line logic. Great circle logic can be specified with `'gc'`.

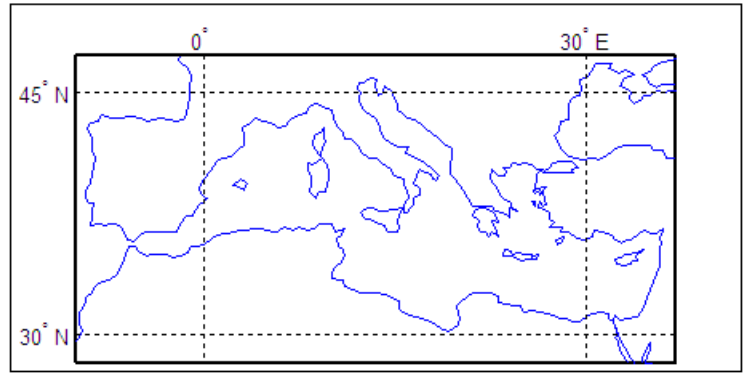
`trkpts = track(lat,lon...)` compresses the output into one two-column matrix, `trkpts`, in which the first column represents latitudes and the second column, longitudes.

Examples

The `track` function is useful for generating data in order to display tracks. Lieutenant Sextant is the navigator of the USS Neversail. He is charged with plotting a track to take Neversail from the Straits of Gibraltar to Port Said, Egypt, the northern end of the Suez Canal. He has picked appropriate waypoints and now would like to display the track for his captain's approval.

First, display a chart of the Mediterranean Sea:

```
load coast
axesm('mercator','MapLatLimit',[28 47],'MapLonLimit',[-10 37],...
    'Grid','on','Frame','on','MeridianLabel','on','ParallelLabel','on')
geoshow(lat,long,'DisplayType','line','color','b')
```



These are the waypoints Lt. Sextant has selected:

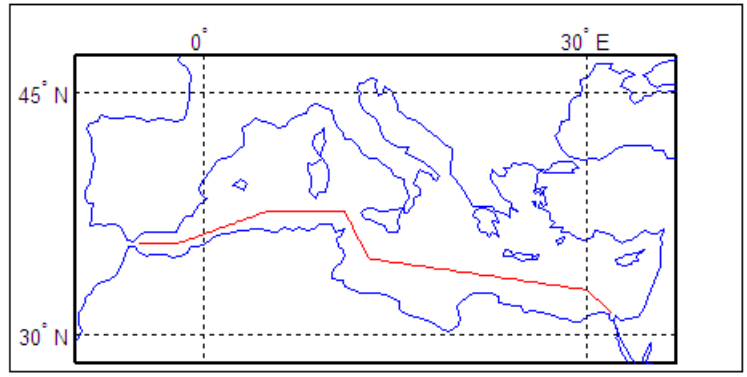
```
waypoints = [36,-5; 36,-2; 38,5; 38,11; 35,13; 33,30; 31.5,32]

waypoints =
```

```
   36.0000   -5.0000
   36.0000   -2.0000
   38.0000    5.0000
   38.0000   11.0000
   35.0000   13.0000
   33.0000   30.0000
   31.5000   32.0000
```

Now display the track:

```
[lttrk,lntrk] = track('rh',waypoints,'degrees');
geoshow(lttrk,lntrk,'DisplayType','line','color','r')
```

With a display this clear, the captain gladly approves the plan.



See Also

`dreckon` | `gcwaypts` | `legs` | `navfix`

Purpose

Geographic tracks from starting point, azimuth, and range

Syntax

```
[lat,lon] = track1(lat0,lon0,az)
[lat,lon] = track1(lat0,lon0,az,arclen)
[lat,lon] = track1(lat0,lon0,az,arclen,ellipsoid)
[lat,lon] = track1(lat0,lon0,az,angleunits)
[lat,lon] = track1(lat0,lon0,az,arclen,angleunits)
[lat,lon] =
track1(lat0,lon0,az,arclen,ellipsoid,angleunits)
[lat,lon] =
track1(lat0,lon0,az,arclen,ellipsoid,angleunits,
   npts)
[lat,lon] = track1(trackstr,...)
mat = track1(...)
```

Description

`[lat,lon] = track1(lat0,lon0,az)` computes complete great circle tracks on a sphere starting at the point `lat0,lon0` and proceeding along the input azimuth, `az`. The inputs can be scalar or column vectors.

`[lat,lon] = track1(lat0,lon0,az,arclen)` uses the input `arclen` to specify the arc length of the great circle track. `arclen` is specified in units of degrees of arc. If `arclen` is a column vector, then the track is computed from the starting point, with positive distance measured easterly. If `arclen` is a two column matrix, then the track is computed starting at the range in the first column and ending at the range in the second column. If `arclen = []`, then the complete track is computed.

`[lat,lon] = track1(lat0,lon0,az,arclen,ellipsoid)` computes the track along a geodesic arc on the ellipsoid defined by the input `ellipsoid`, which can be a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. `arclen` must be expressed in length units that match the units of the semimajor axis — unless `ellipsoid` is `[]` or the semimajor axis length is zero. In these special cases, `arclen` is assumed to be in degrees of arc and the tracks are computed on a sphere, as in the preceding syntax.

`[lat,lon] = track1(lat0,lon0,az,`*`angleunits`*`)`, `[lat,lon] = track1(lat0,lon0,az,arclen,`*`angleunits`*`)`, and `[lat,lon] = track1(lat0,lon0,az,arclen,ellipsoid,`*`angleunits`*`)` use the string `angleunits` to specify the angle units of the inputs and outputs. `angleunits` can equal `'degrees'` or `'radians'`.

`[lat,lon] = track1(lat0,lon0,az,arclen,ellipsoid,`*`angleunits`*`,npts)` uses the scalar input `npts` to specify the number of points per track. The default value of `npts` is 100.

`[lat,lon] = track1(`*`trackstr`*`,...)` uses the string `trackstr` to define either a great circle or rhumb line track. `trackstr` can equal `'gc'` or `'rh'`. If `trackstr` is `'gc'`, then either great circle (given a sphere) or geodesic (given an ellipsoid) tracks are computed. If `trackstr` is `'rh'`, then the rhumb line tracks are computed.

`mat = track1(...)` returns a single output argument `mat` such that `mat = [lat lon]`. This is useful if only a single track is computed.

Multiple tracks can be defined from a single starting point by providing scalar `lat0` and `lon0` and column vectors for `az` and `arclen`.

Definitions

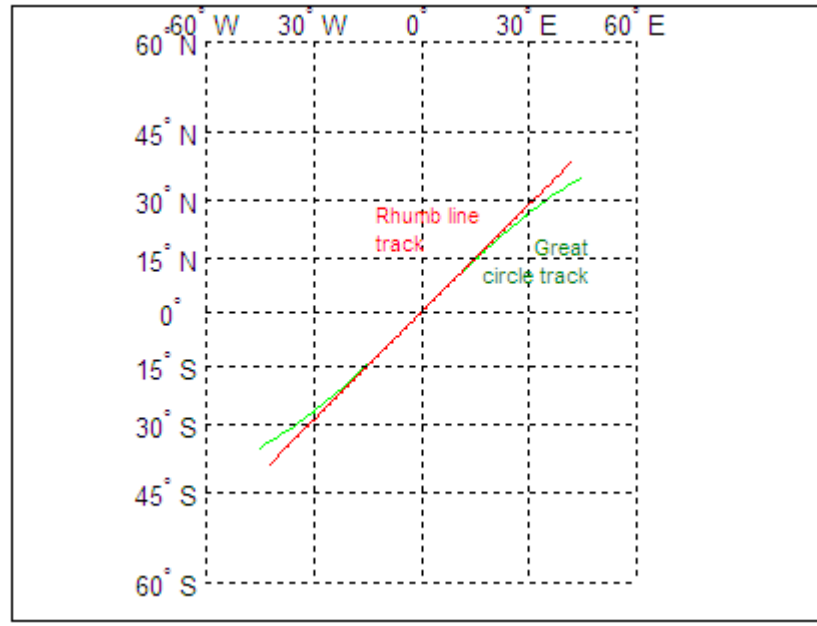
A path along the surface of the Earth connecting two points is a *track*. Two types of track lines are of interest geographically, *great circles* and *rhumb lines*. Great circles represent the shortest possible path between two points. Rhumb lines are paths with constant angular headings. They are not, in general, the shortest path between two points.

Full great circles bisect the Earth; the ends of the track meet to form a complete circle. Rhumb lines with true east or west azimuths are parallels; the ends also meet to form a complete circle. All other rhumb lines terminate at the poles; their ends do not meet.

Examples

```
% Set up the axes.
axesm('mercator','MapLatLimit',[-60 60],'MapLonLimit',[-60 60])
gridm on; plabel on; mlabel on;
```

```
% Plot the great circle track in green.
[lattrkgc,lontrkgc] = track1(0,0,45,[-55 55]);
plotm(lattrkgc,lontrkgc,'g')

% Plot the rhumb line track in red.
[lattrkrh,lontrkrh] = track1('rh',0,0,45,[-55 55]);
plotm(lattrkrh,lontrkrh,'r')
```



See Also

azimuth | distance | reckon | scircle1 | scircle2 | track | track2 | trackg

track2

Purpose

Geographic tracks from starting and ending points

Syntax

```
[lat,lon] = track2(lat1,lon1,lat2,lon2)
[lat,lon] = track2(lat1,lon1,lat2,lon2,ellipsoid)
[lat,lon] = track2(lat1,lon1,lat2,lon2,units)
[lat,lon] = track2(lat1,lon1,lat2,lon2,ellipsoid,units)
[lat,lon] =
track2(lat1,lon1,lat2,lon2,ellipsoid,units,npts)
[lat,lon] = track2(track,...)
mat = track2(...)
```

Description

`[lat,lon] = track2(lat1,lon1,lat2,lon2)` computes great circle tracks on a sphere starting at the point `lat1,lon1` and ending at `lat2,lon2`. The inputs can be scalar or column vectors.

`[lat,lon] = track2(lat1,lon1,lat2,lon2,ellipsoid)` computes the great circle track on the ellipsoid defined by the input `ellipsoid`. `ellipsoid` is a `referenceSphere`, `referenceEllipsoid`, or `oblateSpheroid` object, or a vector of the form `[semimajor_axis eccentricity]`. If `ellipsoid = []`, a sphere is assumed.

`[lat,lon] = track2(lat1,lon1,lat2,lon2,`*`units`*`)` and `[lat,lon] = track2(lat1,lon1,lat2,lon2,ellipsoid,`*`units`*`)` are both valid calling forms, which use the input string *`units`* to define the angle units of the inputs and outputs. If the input string *`units`* is omitted, `'degrees'` is assumed.

`[lat,lon] = track2(lat1,lon1,lat2,lon2,ellipsoid,`*`units`*`,npts)` uses the scalar input `npts` to determine the number of points per track computed. The default value of `npts` is 100.

`[lat,lon] = track2(`*`track`*`,...)` uses the *`track`* string to define either a great circle or a rhumb line track. If *`track`* `= 'gc'`, then great circle tracks are computed. If *`track`* `= 'rh'`, then rhumb line tracks are computed. If the *`track`* string is omitted, `'gc'` is assumed.

`mat = track2(...)` returns a single output argument where `mat = [lat lon]`. This is useful if a single track is computed. Multiple tracks

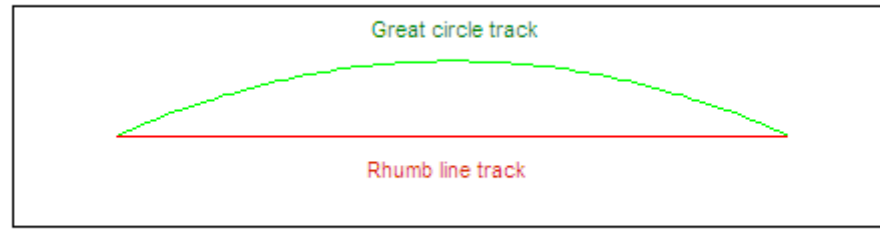
can be defined from a single starting point by providing scalar inputs for `lat1,lon1` and column vectors for `lat2,lon2`.

Definitions

A path along the surface of the Earth connecting two points is a *track*. Two types of track lines are of interest geographically, *great circles* and *rhumb lines*. Great circles represent the shortest possible path between two points. Rhumb lines are paths with constant angular headings. They are not, in general, the shortest path between two points.

Examples

```
% Set up the axes.
axesm('mercator','MapLatLimit',[30 50],'MapLonLimit',[-40 40])

% Calculate the great circle track.
[lattrkgc,lontrkgc] = track2(40,-35,40,35);

% Calculate the rhumb line track.
[lattrkrh,lontrkrh] = track2('rh',40,-35,40,35);

% Plot both tracks.
plotm(lattrkgc,lontrkgc,'g')
plotm(lattrkrh,lontrkrh,'r')
```



See Also

`azimuth` | `distance` | `reckon` | `scircle1` | `scircle2` | `track` | `track1` | `trackg`

trackg

Purpose

Great circle or rhumb line defined via mouse input

Syntax

```
h = trackg(ntrax)
h = trackg(ntrax,npts)
h = trackg(ntrax,linestyle)
h = trackg(ntrax,PropertyName,PropertyValue,...)
[lat,lon] = trackg(ntrax,npts,...)
h = trackg(track,ntrax,...)
```

Description

`h = trackg(ntrax)` brings forward the current map axes and waits for the user to make (2 x `ntrax`) mouse clicks. The output `h` is a vector of handles for the `ntrax` track segments, which are then displayed.

`h = trackg(ntrax,npts)` specifies the number of plotting points to be used for each track segment. `npts` is 100 by default.

`h = trackg(ntrax,linestyle)` specifies the line style for the displayed track segments, where *`linestyle`* is any line style string recognized by the standard MATLAB `line` function.

`h = trackg(ntrax,PropertyName,PropertyValue,...)` allows property name/property value pairs to be set, where *`PropertyName`* and *`PropertyValue`* are recognized by the `line` function.

`[lat,lon] = trackg(ntrax,npts,...)` returns the coordinates of the plotted points rather than the handles of the track segments. Successive segments are stored in separate columns of `lat` and `lon`.

`h = trackg(track,ntrax,...)` specifies the logic with which tracks are calculated. If the string *`track`* is `'gc'` (the default), a great circle path is used. If *`track`* is `'rh'`, rhumb line logic is used.

This function is used to define great circles or rhumb lines for display using mouse clicks. For each track, two clicks are required, one for each endpoint of the desired track segment. You can modify the track after creation by **Shift**+clicking it. The track is then in edit mode, during which you can change the length and position by dragging control points, or by entering values into a control panel. **Shift**+clicking again exits edit mode.

See Also

track1 | track2 | scircleg

trimcart

Purpose

Trim graphic objects to map frame

Syntax

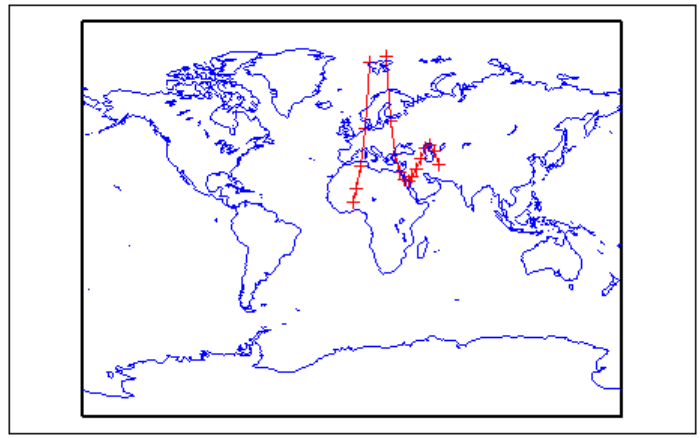
```
trimcart(h)
```

Description

`trimcart(h)` clips the graphic objects to the map frame. `h` can be a handle or a vector of handles to graphics objects. `h` can also be any object name recognized by `handlem`. `trimcart` clips lines, surfaces, and text objects.

Examples

```
figure; axesm('miller')
framem
[x, y] = humps(0:.05:1);
h = plot(x, y/25, 'r+-');
load coast
geoshow(lat, long)
trimcart(h)
```



Limitations

`trimcart` does not trim patch objects.

See Also

`handlem` | `makemapped`

Purpose

Trim map data exceeding projection limits

Syntax

```
[ymat,xmat,trimpts] = trimdata(ymat,ylim,xmat,xlim,'object')
```

Description

`[ymat,xmat,trimpts] = trimdata(ymat,ylim,xmat,xlim,'object')` identifies points in map data that exceed projection limits. The projection limits are defined by the lower and upper inputs. The particular object to be trimmed is identified by the `'object'` input.

Allowable object strings are

- `'surface'` for trimming graticules
- `'light'` for trimming lights,
- `'line'` for trimming lines
- `'patch'` for trimming patches
- `'text'` for trimming text object location points
- `'none'` to skip all trimming operations

See Also

`clipdata` | `undotrim` | `undoclip`

undoclip

Purpose

Remove object clips introduced by `clipdata`

Syntax

```
[lat,long] = undoclip(lat,long,clippts,'object')
```

Description

`[lat,long] = undoclip(lat,long,clippts,'object')` removes the object clips introduced by `clipdata`. This function is necessary to properly invert projected data from the Cartesian space to the original latitude and longitude data points.

The input variable, `clippts`, must be constructed by the function `clipdata`.

Allowable object strings are

- `'surface'` for trimming graticules
- `'light'` for trimming lights
- `'line'` for trimming lines
- `'patch'` for trimming patches
- `'text'` for trimming text object location points
- `'none'` to skip all trimming operations

See Also

`clipdata` | `trimdata` | `undotrim`

Purpose

Remove object trims introduced by `trimdata`

Syntax

```
[ymat,xmat] = undotrim(ymat,xmat,trimpts,'object')
```

Description

`[ymat,xmat] = undotrim(ymat,xmat,trimpts,'object')` removes the object trims introduced by `trimdata`. This function is necessary to properly invert projected data from the Cartesian space to the original latitude and longitude data points.

The input variable, `trimpts`, must be constructed by the function `trimdata`.

Allowable object strings are

- `'surface'` for trimming graticules
- `'light'` for trimming lights
- `'line'` for trimming lines
- `'patch'` for trimming patches
- `'text'` for trimming text object location points
- `'none'` to skip all trimming operations

See Also

`clipdata` | `trimdata` | `undoclip`

Purpose

Unit conversion factors

Syntax

```
ratio = unitsratio(to,from)
```

Description

`ratio = unitsratio(to,from)` returns the number of `to` units per one `from` unit. For example, `unitsratio('cm','m')` returns 100 because there are 100 centimeters per meter. The `unitsratio` function makes it easy to convert from one system of units to another. Specifically, if `x` is in units `from` and

```
y = unitsratio(to, from) * x
```

then `y` is in units `to`.

`to` and `from` can be any strings from the second column of one of the following tables (both must come from the same table). The variables `to` and `from` are case insensitive and can be either singular or plural.

Units of Length

`unitsratio` recognizes the identifiers listed in the `validateLengthUnit` function.

Units of Angle

`unitsratio` recognizes the following identifiers for converting units of angle:

Unit Name	String(s)
radian	`'rad', 'radian(s)'`
degree	`'deg', 'degree(s)'`

Examples

```
% Approximate mean earth radius in meters
radiusInMeters = 6371000

% Conversion factor
feetPerMeter = unitsratio('feet', 'meter')

% Radius in (international) feet:
radiusInFeet = feetPerMeter * radiusInMeters
```

```
% The following prints a true statement for valid TO, FROM pairs:
to   = 'feet';
from = 'mile';
sprintf('There are %g %s per %s.', unitsratio(to,from), to, from)

% The following prints a true statement for valid TO, FROM pairs:
to   = 'degrees';
from = 'radian';
sprintf('One %s is %g %s.', from, unitsratio(to,from), to)
```

unitstr

Purpose

Check spatiotemporal unit strings and abbreviations

Note The `unitstr` function is obsolete and will be removed in a future release. The syntax `str = unitstr(str,'times')` has already been removed.

Syntax

```
unitstr
str = unitstr(str0,'angles')
str = unitstr(str0,'distances')
```

Description

`unitstr`, with no arguments, displays a list of strings and abbreviations, recognized by certain Mapping Toolbox functions, for units of angle and length/distance.

`str = unitstr(str0,'angles')` checks for valid angle unit strings or abbreviations. If a valid string or abbreviation is found, it is converted to a standardized, preset string. `'angles'` can be abbreviated.

`str = unitstr(str0,'distances')` checks for valid length unit strings or abbreviations. If a valid string or abbreviation is found, it is converted to a standardized, preset string. `'distances'` can be abbreviated. Note that input strings `'miles'` and `'mi'` are converted to `'statutemiles'`; there is no way to specify international miles in the `unitstr` function.

Examples

This function recognizes and standardizes certain abbreviations:

```
str = unitstr('sm','distances')
```

```
str =
statutemiles
```

And any unique truncation:

```
str = unitstr('ra','angles')
```

```
str =
radians
```

See Also

unitsratio

unwrapMultipart

Purpose

Unwrap vector of angles with NaN-delimited parts

Syntax

```
unwrapped = unwrapMultipart(p)
unwrapped = unwrapMultipart(p,angleUnit)
```

Description

`unwrapped = unwrapMultipart(p)` unwraps a row or column vector of azimuths, longitudes, or phase angles. Input and output units are both radians. If `p` is separated into multiple parts delimited by values of NaN, each part is unwrapped independently. If `p` has only one part, the result is equivalent to `unwrap(p)`. The output is the same size as the input and has NaNs in the same locations.

`unwrapped = unwrapMultipart(p,angleUnit)` unwraps a row or column vector of azimuths, longitudes, or phase angles, where `angleUnit` specifies the unit used for the input and output angles: `'degrees'` or `'radians'`.

Examples

Example 1

Compare the behavior `unwrapMultipart` to that of `unwrap`. The output of `unwrapMultipart` starts over again at 6.11 following the NaN, unlike the output of `unwrap`. The output of `unwrapMultipart` is equivalent to a concatenation (with NaN-separator) of separate calls to `unwrap`:

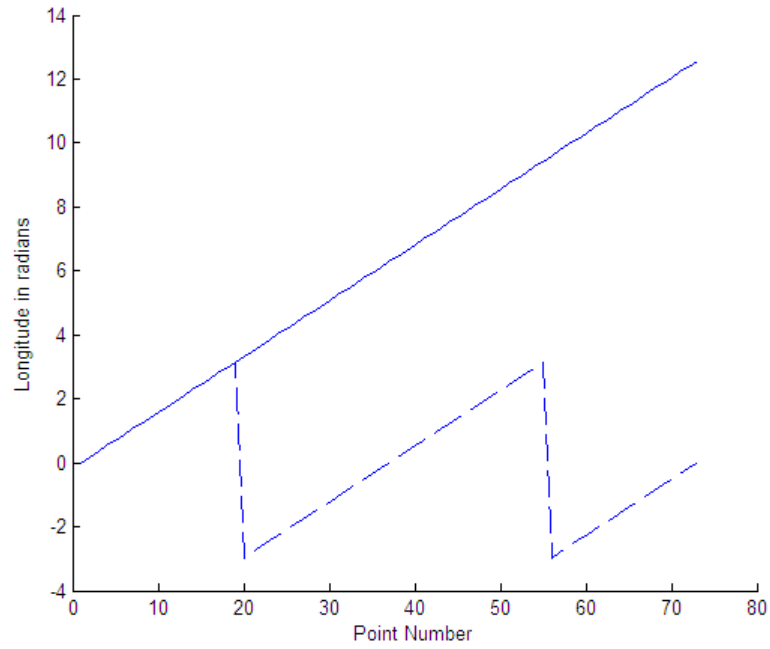
```
p1 = [0.17          5.67          4.89          4.10];
p2 = [6.11          1.05          2.27];
unwrap([p1 NaN p2])

ans =
    0.1700   -0.6132   -1.3932   -2.1832       NaN   -0.1732    1.0500    2.2700

unwrapMultipart([p1 NaN p2])

ans =
    0.1700   -0.6132   -1.3932   -2.1832       NaN    6.1100    7.3332    8.5532

[unwrap(p1) NaN unwrap(p2)]
```

```
ans =
    0.1700   -0.6132   -1.3932   -2.1832       NaN    6.1100    7.3332    8.5532
```

Example 2

Wrap two revolutions of a sphere to π with `wrapToPi`, and then unwrap it with `unWrapMultipart`:

```
lon = wrapToPi(degtorad(0:10:720));
unwrappedlon = unwrapMultipart(lon);
figure; hold on
plot(lon,'--')
plot(unwrappedlon)
xlabel 'Point Number'
ylabel 'Longitude in radians'
```



See Also unwrap | wrapTo180 | wrapTo360 | wrapToPi | wrapTo2Pi

Purpose

Convert line or patch display structure to geostruct

Syntax

```
geostruct = updategeostruct(displaystruct)
geostruct = updategeostruct(displaystruct, str)
[geostruct,symbolspec] = updategeostruct(displaystruct, ...)
[geostruct,symbolspec] = updategeostruct(displaystruct, ...,
   cmap)
```

Description

`geostruct = updategeostruct(displaystruct)` accepts a Mapping Toolbox display structure `displaystruct`. If `displaystruct` is a vector display structure for which the `'type'` field has value `'line'` or `'patch'`, `updategeostruct` restructures its elements to create a geostruct, `geostruct`. If `displaystruct` is a already geographic data structure, it is copied unaltered to `geostruct`. `updategeostruct` does not update display structure arrays of type `'text'`, `'light'`, `'regular'`, or `'surface'`.

`geostruct = updategeostruct(displaystruct, str)` selects only elements whose `tag` field begins with the string `str` (and whose `type` field is either `'line'` or `'patch'`). The selection is case insensitive.

`[geostruct,symbolspec] = updategeostruct(displaystruct, ...)` restructures a display structure and determines a symbolspec based on the graphic properties specified in the `otherproperty` field for each element of `displaystruct` and, if necessary, the `jet` colormap.

`[geostruct,symbolspec] = updategeostruct(displaystruct, ..., cmap)` specifies a colormap, `cmap`, to define the colors used in symbolspec.

Tips

There are two Mapping Toolbox encodings for vector features that use MATLAB structure arrays. In both cases there is one feature per array element, and in both cases a given array's elements all held the same type of feature. Version 1.3.1 and earlier of the Mapping Toolbox software only supported Mapping Toolbox display structures. Version 2.0 introduced a data structure for vector geodata which was less rigidly defined and more open-ended. The new structures are called *geostructs* (if they contain geographic coordinate data) and *mapstructs* (if they

contain projected coordinate data). Over time, display structures are being phased out of the toolbox; the `updategeostruct` function is provided to help users migrate from the old display structure format to the current geostruct/mapstruct format.

A Version 1 Mapping Toolbox display structure is a MATLAB structure that can contain line, patch, text, regular data grid, geolocated data grid, and light objects. The `displaym` function does not accept geostructs produced by Version 2 of the Mapping Toolbox software.

Display structures for lines and patches and Line and Polygon geostructs have the following things in common:

- A field that specifies the type of feature geometry:
  - A `type` field a display structure (value: `'line'` or `'patch'`)
  - A `Geometry` field for a geostruct (value: 'Line' or `'Polygon'`)
- A latitude field:
  - `lat` for a display structure
  - `Lat` for a geostruct
- A longitude field:
  - `long` for a display structure
  - `Lon` for a geostruct

In terms of their differences,

- A geostruct has a `BoundingBox` field; there is no display structure counterpart for this
- A geostruct typically has one or more "attribute" fields, whose values must be either scalar doubles or strings, with arbitrary field names. The presence or absence of a given attribute field—and its value—is dependent on the specific data set that the geostruct represents.
- A (line or patch) display structure has the following fields:
  - A `tag` field that names an individual feature or object
  - An `altitude` coordinate array that extends coordinates to 3-D

- An `otherproperty` field in which MATLAB graphics can be specified explicitly, on a per-feature basis

Object properties used in the display are taken from the `otherproperty` field of the structure. If a line or patch object's `otherproperty` field is empty, `displaym` uses default colors. A patch is assigned an index into the current colormap based on the structure's `tag` field. Lines are assigned colors from the current color order according to their tags.

The newer geostruct representation has significant advantages:

- It can represent a much wider range of attributes (display structures essentially can represent only a feature name).
- The geostruct representation (in combination with `geoshow` and `makesymbolspec`) keeps graphics display properties separate from the intrinsic properties of the geographic features themselves.

For example, a road-class attribute can be used to display major highways with a distinctive color and greater line width than secondary roads. The same geographic data structure can be displayed in many different ways, without altering any of its contents, and shapefile data imported from external sources need not be altered to control its graphic display.

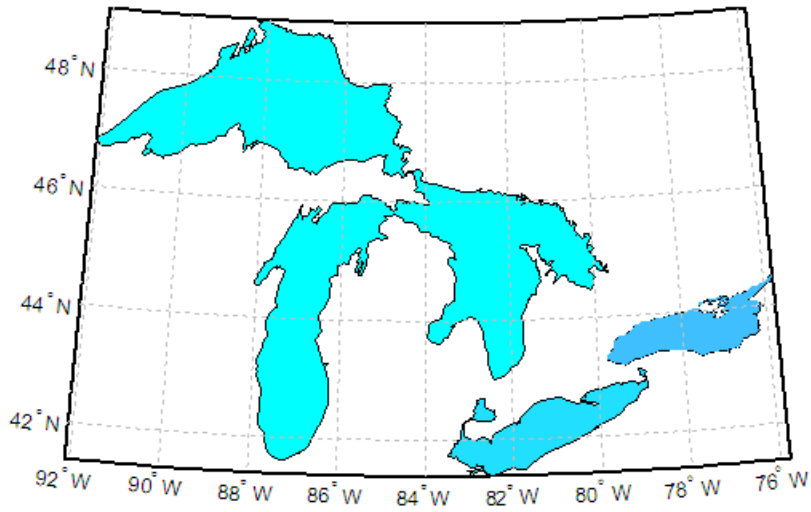
For information about the display structure format, see "Version 1 Display Structures" on page 3-177 in the reference page for `displaym`. For a discussion of the characteristics of geographic data structures, see "Mapping Toolbox Geographic Data Structures" in the *Mapping Toolbox User's Guide*.

Examples

Update and display the Great Lakes display structure to a geostruct:

```
load greatlakes
cmap = cool(3*numel(greatlakes));
[gtlakes, spec] = updategeostruct(greatlakes, cmap);
lat = extractfield(gtlakes,'Lat');
lon = extractfield(gtlakes,'Lon');
lonlim = [min(lon) max(lon)];
latlim = [min(lat) max(lat)];
figure
```

```
usamap(latlim, lonlim);
geoshow(gtlakes, 'SymbolSpec', spec)
```



See Also

displaym | geoshow | makesymbolspec | mapshow | mapview | shaperead

Purpose

Construct map axes for United States of America

Syntax

```
usamap state
usamap(state)
usamap 'conus'
usamap('conus')
usamap
usamap(latlim, lonlim)
usamap(Z, R)
h = usamap(...)
h = usamap('all')
```

Description

`usamap state` or `usamap(state)` constructs an empty map axes with a Lambert Conformal Conic projection and map limits covering a U.S. state or group of states specified by input `state`. `state` may be a string or a cell array of strings, where each string contains the name of a state or `'District of Columbia'`. Alternatively, `state` may be a standard two-letter U.S. Postal Service abbreviation. The map axes is created in the current axes and the axis limits are set tight around the map frame.

`usamap 'conus'` or `usamap('conus')` constructs an empty map axes for the conterminous 48 states (i.e. excluding Alaska and Hawaii).

`usamap` with no arguments asks you to choose from a menu of state names plus `'District of Columbia'`, `'conus'`, and `'all'`.

`usamap(latlim, lonlim)` constructs an empty Lambert Conformal map axes for a region of the U.S. defined by its latitude and longitude limits in degrees. `latlim` and `lonlim` are two-element vectors of the form `[southern_limit northern_limit]` and `[western_limit eastern_limit]`, respectively.

`usamap(Z, R)` derives the map limits from the extent of a regular data grid georeferenced by `R`. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel.

`h = usamap(...)` returns the handle of the map axes.

`h = usamap('all')` constructs three empty axes, inset within a single figure, for the conterminous states, Alaska, and Hawaii, with a spherical Earth model and other projection parameters suggested by the U.S. Geological Survey. The maps in the three axes are shown at approximately the same scale. The handles for the three map axes are returned in `h`. `h(1)` is for the conterminous states, `h(2)` is for Alaska, and `h(3)` is for Hawaii. `usamap('allequal')`is the same as `usamap('all')`; usage of `'allequal'` will be removed in a future release.

All axes created with `usamap` are initialized with a spherical Earth model having a radius of 6,371,000 meters.

Tips

In some cases, `usamap` uses `tightmap` to adjust the axis limits tight around the map. If you change the projection, or just want more white space around the map frame, use `tightmap` again or `axis auto`.

`axes(h(n))`, where `n = 1`, `2`, or `3`, makes the desired axes current.

`set(h,'Visible','on')` makes the axes visible.

`set(h,'ButtonDownFcn','selectmoveresize')` allows interactive repositioning of the axes. `set(h,'ButtonDownFcn','uimaptbx')` restores the Mapping Toolbox interfaces.

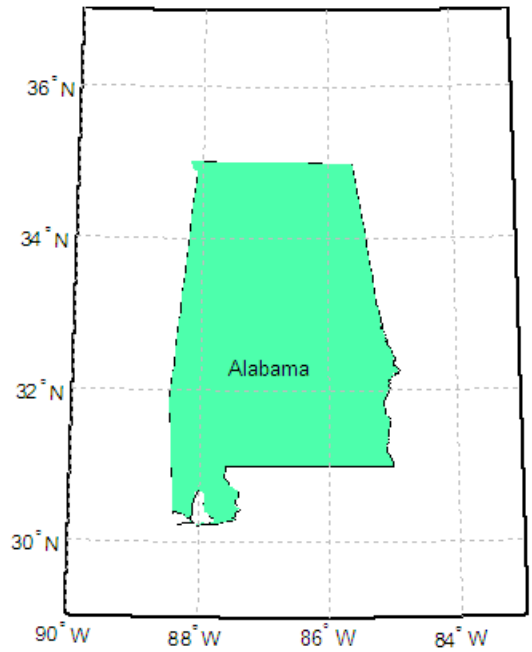
`axesscale(h(1))` resizes the axes containing Alaska and Hawaii to the same scale as the conterminous states.

Examples

Example 1

Make a map of Alabama only:

```
usamap('Alabama')
alabamahi = shaperead('usastatehi', 'UseGeoCoords', true,...
            'Selector',{@(name) strcmpi(name,'Alabama'), 'Name'});
geoshow(alabamahi, 'FaceColor', [0.3 1.0, 0.675])
textm(alabamahi.LabelLat, alabamahi.LabelLon, alabamahi.Name,...
  'HorizontalAlignment', 'center')
```

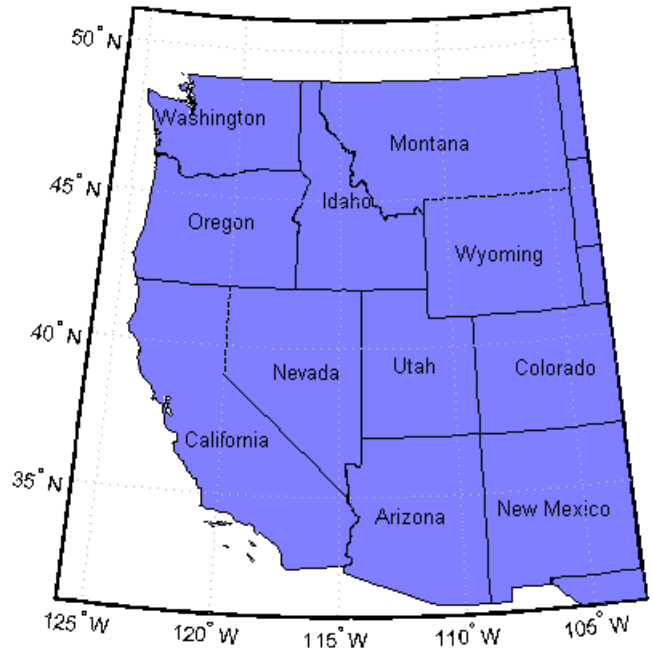


Example 2

Map a region extending from California to Montana:

```
figure; ax = usamap({'CA','MT'});
```

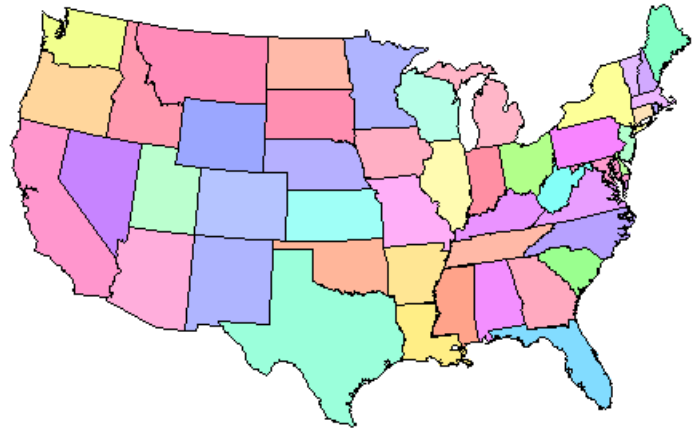
```
set(ax, 'Visible', 'off')
latlim = getm(ax, 'MapLatLimit');
lonlim = getm(ax, 'MapLonLimit');
states = shaperead('usastatehi',...
        'UseGeoCoords', true, 'BoundingBox', [lonlim', latlim']);
geoshow(ax, states, 'FaceColor', [0.5 0.5 1])

lat = [states.LabelLat];
lon = [states.LabelLon];
tf = ingeoquad(lat, lon, latlim, lonlim);
textm(lat(tf), lon(tf), {states(tf).Name}, ...
   'HorizontalAlignment', 'center')
```



Example 3

Map the Conterminous United States with a different fill color for each state:

```
figure; ax = usamap('conus');
states = shaperead('usastatelo', 'UseGeoCoords', true,...
  'Selector',...
  {@(name) ~any(strcmp(name,{'Alaska','Hawaii'})), 'Name'});
faceColors = makesymbolspec('Polygon',...
    {'INDEX', [1 numel(states)], 'FaceColor', ...
    polcmap(numel(states))}); %NOTE - colors are random
geoshow(ax, states, 'DisplayType', 'polygon', ...
   'SymbolSpec', faceColors)
framem off; gridm off; mlabel off; plabel off
```

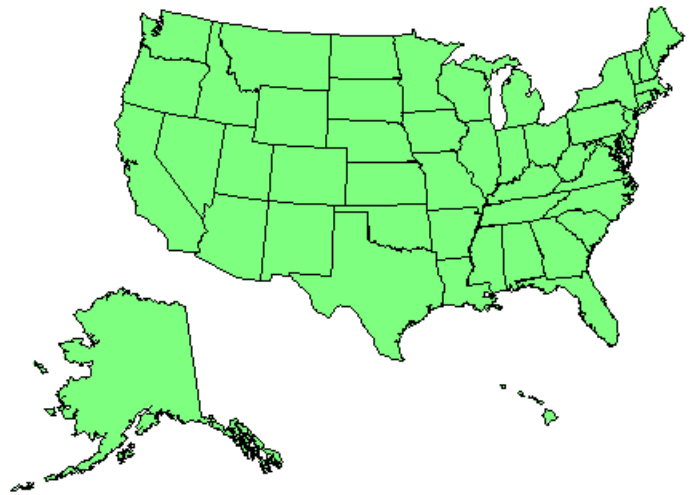


Example 4

Map of the USA with separate axes for Alaska and Hawaii:

```
figure; ax = usamap('all');
set(ax, 'Visible', 'off')
```

```
states = shaperead('usastatelo', 'UseGeoCoords', true);
names = {states.Name};
indexHawaii = strcmp('Hawaii',names);
indexAlaska = strcmp('Alaska',names);
indexConus = 1:numel(states);
indexConus(indexHawaii|indexAlaska) = [];
stateColor = [0.5 1 0.5];
geoshow(ax(1), states(indexConus),  'FaceColor', stateColor)
geoshow(ax(2), states(indexAlaska), 'FaceColor', stateColor)
geoshow(ax(3), states(indexHawaii), 'FaceColor', stateColor)
for k = 1:3
    setm(ax(k), 'Frame', 'off', 'Grid', 'off',...
      'ParallelLabel', 'off', 'MeridianLabel', 'off')
end
```



See also

axesm, axesscale, geoshow, paperscale, selectmoveresize, tightmap, worldmap

Purpose

Read USGS 7.5-minute (30-m or 10-m) Digital Elevation Models

Syntax

```
[lat,lon,Z] = usgs24kdem
[lat,lon,Z] = usgs24kdem(filename)
[lat,lon,Z] = usgs24kdem(filename,samplefactor)
[lat,lon,Z] =
usgs24kdem(filename,samplefactor,latlim,lonlim)
[lat,lon,Z] = ...usgs24kdem(filename,samplefactor,latlim,
   lonlim,gsize)
[lat, lon, Z, header, profile] = usgs24kdem(...)
```

Description

`[lat,lon,Z] = usgs24kdem` reads a USGS 1:24,000 digital elevation map (DEM) file in standard format. The file is selected interactively. The entire file is read and subsampled by a factor of 5. A geolocated data grid is returned with a latitude array, `lat`, longitude array, `lon`, and elevation array, `Z`. Horizontal units are in degrees, vertical units may vary. The 1:24,000 series of DEMs are stored as a grid of elevations spaced either at 10 or 30 meters apart. The number of points in a file will vary with the geographic location.

`[lat,lon,Z] = usgs24kdem(`*`filename`*`)` reads the USGS DEM specified by *`filename`* and returns the result as a geolocated data grid.

`[lat,lon,Z] = usgs24kdem(`*`filename`*`,samplefactor)` reads a subset of the DEM data from *`filename`*. `samplefactor` is a scalar integer, which when equal to 1 reads the data at its full resolution. When `samplefactor` is an integer `n` greater than one, every `n`th point is read. If `samplefactor` is omitted or empty, it defaults to `5`.

`[lat,lon,Z] =`
`usgs24kdem(`*`filename`*`,samplefactor,latlim,lonlim)` reads a subset of the elevation data from *`filename`*. The limits of the desired data are specified as two-element vectors of latitude, `latlim`, and longitude, `lonlim`, in degrees. The elements of `latlim` and `lonlim` must be in ascending order. The data may extend somewhat outside the requested area. If limits are omitted, data for the entire area covered by the DEM file is returned.

`[lat,lon,Z] = ...usgs24kdem(`*`filename`*`,samplefactor,latlim,lonlim,gsize)` specifies the graticule size in `gsize`. `gsize` is a two-element vector specifying the number of rows and columns in the latitude and longitude coordinated grid. If omitted, a graticule the same size as the geolocated data grid is returned. Use empty matrices for `latlim` and `lonlim` to specify the coordinated grid size without specifying the geographic limits.

`[lat, lon, Z, header, profile] = usgs24kdem(...)` also returns the contents of the header and raw profiles of the DEM file. The `header` structure contains descriptions of the data from the file header. The `profile` structure is the raw profile data from which the geolocated data grid is constructed.

Background

The U.S. Geological Survey has created a series of digital elevation models based on their paper 1:24,000 scale maps. The grid spacing for these elevations models is either 10 or 30 meters on a Universal Transverse Mercator grid. Each file covers a 7.5 minute quadrangle. The map and data series are available for much of the conterminous United States, Hawaii, and Puerto Rico. The data has been released in a number of formats. This function reads the data in the “standard” file format.

Examples

Use the archived San Francisco South 24K DEM file `sanfranciscos.dem.gz`, which is provided in the Mapping Toolbox `mapdata` folder.

1. Gunzip the file to a temporary folder:

```
filenames = gunzip('sanfranciscos.dem.gz', tempdir);
demFilename = filenames{1};
```

2. Read every other point of the 1:24,000 DEM file.

```
[lat, lon,Z,header,profile] = usgs24kdem(demFilename,2);
```

3. Delete the temporary gunzipped file.

```
delete(demFilename);
```

4 As no negative elevations exist, move all points at sea level to -1 to color them blue:

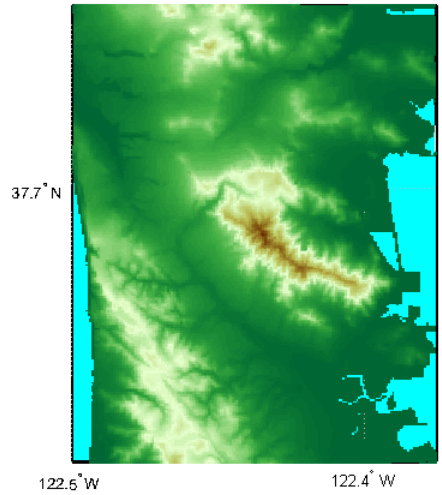
```
Z(Z==0) = -1;
```

5 Compute the latitude and longitude limits for the DEM:

```
latlim = [min(lat(:)) max(lat(:))]

latlim =
   37.6249   37.7504

lonlim = [min(lon(:)) max(lon(:))]

lonlim =
 -122.5008 -122.3740
```

6 Display the DEM values:

```
figure
usamap(latlim, lonlim)
geoshow(lat, lon, Z, 'DisplayType','surface')
demcmap(Z)
daspectm('m',1)
```



7 Examine the metadata in the header:

```
header

header =
                     Quadranglename: 'SAN FRANCISCO SOUTH, CA
                                      BIG BASIN DEM'
                        TextualInfo: 'WMC                 CTOG'
                             Filler: ''
                        ProcessCode: ''
                            Filler2: ''
                  SectionalIndicator: ''
                        MCoriginCode: ''
                        DEMlevelCode: 2
                ElevationPatternCode: 'regular'
    PlanimetricReferenceSystemCode: 'UTM'
                                Zone: 10
              ProjectionParameters: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
                   HorizontalUnits: 'meters'
                    ElevationUnits: 'feet'
```

```
NsidesToBoundingBox: 4
        BoundingBox: [1x8 double]
   MinMaxElevations: [0 1314]
      RotationAngle: 0
       AccuracyCode: 'accuracy information in record C'
     XYZresolutions: [30 30 1]
          NrowsCols: [1 371]
     MaxPcontourInt: NaN
 SourceMaxCintUnits: NaN
    SmallestPrimary: NaN
 SourceMinCintUnits: NaN
     DataSourceDate: NaN
    DataInspRevDate: NaN
        InspRevFlag: ''
 DataValidationFlag: NaN
    SuspectVoidFlag: NaN
      VerticalDatum: NaN
    HorizontalDatum: NaN
        DataEdition: NaN
        PercentVoid: NaN
```

Tips

This function reads USGS DEM files stored in the UTM projection. The function unprojects the grid back to latitude and longitude. Use `usgsdem` for data stored in geographic grids.

The number of points in a file varies with the geographic location. Unlike the USGS DEM products, which use an equal-angle grid, the UTM projection grid DEMs cannot simply be concatenated to cover larger areas. There can be data gaps between DEMs.

You can obtain the data files from the U.S. Geological Survey and from commercial vendors . Other agencies have made some local area data available online. See http://www.mathworks.com/help/map/finding-geospatial-data.html . The DEM files are ASCII files, and can be transferred as text. Line-ending conversion is not necessarily required.

See Also

`demdataui` | `dted` | `gtopo30` | `tbase` | `etopo` | `usgsdem` | `usgsdems`

usgsdem

Purpose

Read USGS 1-degree (3-arc-second) Digital Elevation Model

Syntax

```
[Z,refvec] = usgsdem(filename,scalefactor)
[Z,refvec] = usgsdem(filename,scalefactor,latlim,lonlim)
```

Description

`[Z,refvec] = usgsdem(filename,scalefactor)` reads the specified file and returns the data in a regular data grid along with referencing vector `refvec`, a 1-by-3 vector having elements `[cells/degree north-latitude west-longitude]` with latitude and longitude limits specified in degrees. The data can be read at full resolution (`scalefactor` = 1), or can be downsampled by the `scalefactor`. A `scalefactor` of 3 returns every third point, giving 1/3 of the full resolution.

`[Z,refvec] = usgsdem(filename,scalefactor,latlim,lonlim)` reads data within the latitude and longitude limits. These limits are two-element vectors with the minimum and maximum values specified in units of degrees.

Background

The U.S. Geological Survey has made available a set of digital elevation maps of 1-degree quadrangles covering the contiguous United States, Hawaii, and limited portions of Alaska. The data is on a regular grid with a spacing of 30 arc-seconds (or about 100-meter resolution). 1-degree DEMs are also referred to as *3-arc-second* or *1:250,000 scale* DEM data.

The data is derived from the U.S. Defense Mapping Agency's DTED-1 digital elevation model, which itself was derived from cartographic and photographic sources. The cartographic sources were maps from the 7.5-minute through 1-degree series (1:24,000 scale through 1:250,000 scale).

Tips

The grid for the digital elevation maps is based on the 1984 World Geodetic System (WGS84). Older DEMs were based on WGS72. Elevations are in meters relative to National Geodetic Vertical Datum of 1929 (NGVD 29) in the continental U.S. and local mean sea level in Hawaii.

The absolute horizontal accuracy of the DEMs is 130 meters, while the absolute vertical accuracy is ±30 meters. The relative horizontal and vertical accuracy is not specified, but is probably much better than the absolute accuracy.

These DEMs have a grid spacing of 3 arc-seconds in both the latitude and longitude directions. The exception is DEM data in Alaska, where latitudes between 50 and 70 degrees North have grid spacings of 6 arc-seconds, and latitudes greater than 70 degrees North have grid spacings of 9 arc-seconds.

Statistical data in the files is not returned.

You can obtain the data files from the U.S. Geological Survey and from commercial vendors. Other agencies have made some local area data available online.

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: http://www.mathworks.com/help/map/finding-geospatial-data.html

---

Examples

Read every fifth point in the file containing part of Rhode Island and Cape Cod:

```
[Z,refvec] = usgsdem('providence-e',5);
```

Read the elevation data for Martha's Vineyard at full resolution:

```
[Z,refvec] = usgsdem('providence-e',1,...
 [41.2952 41.4826],[-70.8429 -70.4392]);
whos Z
```

```
  Name        Size          Bytes  Class

  Z         226x485        876880  double array
```

See Also

usgs24kdem | gtopo30 | etopo | tbase | usgsdems

usgsdems

Purpose

USGS 1-degree (3-arc-sec) DEM filenames for latitude-longitude quadrangle

Syntax

```
[fname,qname] = usgsdems(latlim,lonlim)
```

Description

`[fname,qname] = usgsdems(latlim,lonlim)` returns cell arrays of the DEM filenames and quadrangle names covering the geographic region. The region is specified by scalar latitude and longitude points or two-element vectors of latitude and longitude limits in units of degrees.

Background

The U.S. Geological Survey has made available a set of digital elevation maps of 1-degree quadrangles covering the contiguous United States, Hawaii, and limited portions of Alaska. These are referred to as *1-degree*, *3-arc second* or *1:250,000 scale* DEMs. Because the filenames of these 1 degree data sets are taken from the names of cities or features in the quadrangle, determining the files needed to cover a particular region generally requires consulting an index map or other reference. This function takes the place of such a reference by returning the filenames for a given geographic region.

Tips

This function only returns filenames for the contiguous United States.

Examples

Which files are needed to map part of New England?

```
usgsdems([41 44], [-72 -69])

ans =
    'providence-w'
    'providence-e'
    'chatham-w'
    'boston-w'
    'boston-e'
    'portland-w'
    'portland-e'
    'bath-w'
```

See Also

usgsdem

utmgeoid

Purpose

Select ellipsoids for given UTM zone

Syntax

```
ellipsoid = utmgeoid,
ellipsoid = utmgeoid(zone)
[ellipsoid,ellipsoidstr] = utmgeoid(...)
```

Description

The purpose of this function is to recommend a local ellipsoid for use with a given UTM zone, depending on the geographic location of that zone. Use it only if you are not using a global reference ellipsoid, such as the World Geodetic System (WGS) 1984 ellipsoid. In many cases, depending on your application, you should just use the output of `wgs84Ellipsoid`, or one of the other options available through `referenceEllipsoid`.

`ellipsoid = utmgeoid,` without any arguments, opens the `utmzoneui` interface for selecting a UTM zone. This zone is then used to return the recommended ellipsoid definitions for that particular zone.

`ellipsoid = utmgeoid(`*`zone`*`)` uses the input *`zone`* to return the recommended ellipsoid definitions.

`[ellipsoid,ellipsoidstr] = utmgeoid(...)` returns the short name(s) for the reference ellipsoid(s), as used by `referenceEllipsoid`, in a `char` array with one name in each row.

Background

The Universal Transverse Mercator (UTM) system of projections tiles the world into quadrangles called zones. Each zone has different projection parameters and commonly used ellipsoidal models of the Earth. This function returns a list of ellipsoid models commonly used in a zone.

Examples

```
zone = utmzone(0,100) % degrees

zone =
47N

[ellipsoid,names] = utmgeoid(zone)
```

```
ellipsoid =
       6377.3     0.081473
       6377.4     0.081697
names =
everest
bessel
```

See Also

referenceEllipsoid | wgs84Ellipsoid

Purpose

Select UTM zone given latitude and longitude

Syntax

```
zone = utmzone
zone = utmzone(lat,long)
zone = utmzone(mat),
[latlim,lonlim] = utmzone(zone),
lim = utmzone(zone)
```

Description

`zone = utmzone` selects a Universal Transverse Mercator (UTM) zone with a graphical user interface. The zone designation is returned as a string.

`zone = utmzone(lat,long)` returns the UTM zone containing the geographic coordinates. If `lat` and `long` are vectors, the zone containing the geographic mean of the data set is returned. The geographic coordinates must be in units of degrees.

`zone = utmzone(mat),` where `mat` is of the form `[lat long]`.

`[latlim,lonlim] = utmzone(zone),` where *`zone`* is a valid UTM zone designation, returns the geographic limits of the zone. Valid UTM zones designations are numbers, or numbers followed by a single letter. For example, `'31'` or `'31N'`. The returned limits are in units of degrees.

`lim = utmzone(zone)` returns the limits in a single vector output.

Background

The Universal Transverse Mercator (UTM) system of projections tiles the world into quadrangles called zones. This function can be used to identify which zone is used for a geographic area and, conversely, what geographic limits apply to a UTM zone.

Examples

```
[latlim,lonlim] = utmzone('12F')

latlim =
   -56   -48
lonlim =
  -114  -108
```

```
utmzone(latlim,lonlim)

ans =
12F
```

Limitations

The UTM zone system is based on a regular division of the globe, with the exception of a few zones in northern Europe. `utmzone` does not account for these deviations.

See Also

`utmgeoid`

validateLengthUnit

Purpose

Validate and standardize length unit string

Syntax

```
standardName = validateLengthUnit(unit, funcName, varName,
   argIndex)
```

Description

`standardName = validateLengthUnit(unit, funcName, varName, argIndex)` checks that `unit` is a valid length unit string and converts it to a standard unit name. The function is case-insensitive with respect to its input. Spaces, periods, and apostrophes are ignored. Plural forms are accepted in most cases, but the result, `standardName` is always singular. The optional inputs `funcName`, `varName`, and `argIndex` may be included for use in error message formatting, with behavior identical to that provided by the `validateattributes` inputs of the same names.

Input Arguments

unit

String. Any valid length unit string listed in the table.

Unit Name	String(s)
meter	`m', `meter(s)', `metre(s)'
centimeter	`cm', `centimeter(s)', `centimetre(s)'
millimeter	`mm', `millimeter(s)', `millimetre(s)'
micron	`micron(s)'
kilometer	`km', `kilometer(s)', `kilometre(s)'
nautical mile	`nm', `naut mi', `nautical mile(s)'
foot	`ft', `international ft', `foot', `international foot', 'feet', `international feet'
inch	`in', `inch', `inches'

Unit Name	String(s)
yard	`yd', `yds', `yard(s)'
mile	`mi', `mile(s)', `international mile(s)'
U.S. survey foot	`sf', `survey ft', `US survey ft', `U.S. survey ft', `survey foot', `US survey foot', `U.S. survey foot', `survey feet', `US survey feet', `U.S. survey feet'
U.S. survey mile (statute mile)	`sm', `survey mile(s)', `statute mile(s)', `US survey mile(s)', `U.S. survey mile(s)'
Clarke's foot	`Clarke's foot', `Clarkes foot'
German legal metre	`German legal metre', `German legal meter'
Indian foot	`Indian foot'

funcName

String that specifies the name of the function whose input you are validating. If you specify an empty string, `''`, the `validateLengthUnit` function ignores the `funcName` input.

varName

String that specifies the name of the input variable. If you specify an empty string, `''`, the `validateLengthUnit` function ignores the `varName` input.

argIndex

Positive integer that specifies the position of the input argument.

Output Arguments

standardName

String that specifies the standard unit name for the input string.

Examples

Validate 'foot'

This example shows you how 'foot' is validated when other valid strings for 'foot' are input.

```
validateLengthUnit('foot')
validateLengthUnit('feet')
validateLengthUnit('international feet')
```

```
ans =

foot


ans =

foot


ans =

foot
```

Validate 'kilometer'

This example shows you how 'kilometer' is validated when other valid strings for 'kilometer' are input.

```
validateLengthUnit('kilometer')
validateLengthUnit('km')
```

```
    validateLengthUnit('kilometre')
    validateLengthUnit('kilometers')
    validateLengthUnit('kilometres')

ans =

kilometer


ans =

kilometer


ans =

kilometer


ans =

kilometer


ans =

kilometer
```

Create custom error messages

Create custom error messages using the `validateLengthUnit` function. A non-char input to `validateLengthUnit` results in an error message referencing a function name, '`FOO`', a variable name, '`unit`' and an argument number, 5.

```
validateLengthUnit(17,'FOO','UNIT',5)
```

```
Error using FOO
Expected input number 5, UNIT, to be one of these types:

  char

Instead its type was double.

Error in validateLengthUnit (line 85)
validateattributes(unit,{'char'},{'nonempty','row'},varargin{:})
```

See Also

unitsratio

Purpose

Convert latitude-longitude vectors to regular data grid

Syntax

```
[Z, R] = vec2mtx(lat, lon, density)
[Z, R] = vec2mtx(lat, lon, density, latlim, lonlim)
[Z, R] = vec2mtx(lat, lon, Z1, R1)
[Z, R] = vec2mtx(..., 'filled')
```

Description

`[Z, R] = vec2mtx(lat, lon, density)` creates a regular data grid `Z` from vector data, placing ones in grid cells intersected by a vector and zeroes elsewhere. `R` is the referencing vector for the computed grid. `lat` and `lon` are vectors of equal length containing geographic locations in units of degrees. `density` indicates the number of grid cells per unit of latitude and longitude (a value of 10 indicates 10 cells per degree, for example), and must be scalar-valued. Whenever there is space, a buffer of two grid cells is included on each of the four sides of the grid. The buffer is reduced as needed to keep the latitudinal limits within [-90 90] and to keep the difference in longitude limits from exceeding 360 degrees.

`[Z, R] = vec2mtx(lat, lon, density, latlim, lonlim)` uses the two-element vectors `latlim` and `lonlim` to define the latitude and longitude limits of the grid.

`[Z, R] = vec2mtx(lat, lon, Z1, R1)` uses a pre-existing data grid `Z1`, georeferenced by `R1`, to define the limits and density of the output grid. `R1` can be a referencing vector, a referencing matrix, or a `spatialref.GeoRasterReference` object.

If `R1` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z1)` and its `RasterInterpretation` must be `'cells'`.

If `R1` is a referencing vector, it must be a 1-by-3 vector containing elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

or a 3-by-2 referencing matrix that transforms raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R1
```

If `R1` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel. With this syntax, output `R` is equal to `R1`, and may be a referencing object, vector, or matrix.

`[Z, R] = vec2mtx(..., 'filled')`, where `lat` and `lon` form one or more closed polygons (with `NaN`-separators), fills the area outside the polygons with the value two instead of the value zero.

Notes

Empty `lat,lon` vertex arrays will result in an error unless the grid limits are explicitly provided (via `latlim,lonlim` or `Z1,R1`). In the case of explicit limits, `Z` will be filled entirely with 0s if the `'filled'` parameter is omitted, and 2s if it is included.

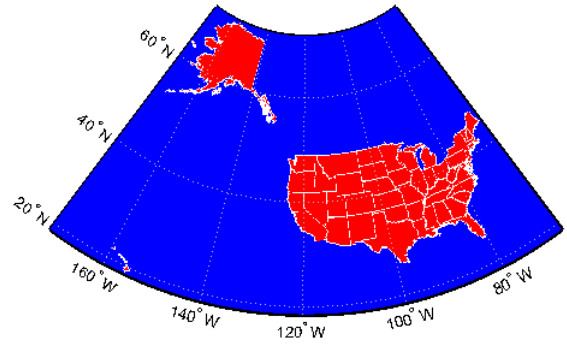
It's possible to apply `vec2mtx` to sets of polygons that tile without overlap to cover an area, as in Example 1 below, but using `'filled'` with polygons that actually overlap may lead to confusion as to which areas are inside and which are outside.

Examples

Example 1

Convert latitude-longitude polygons to a regular data grid and display as a map.

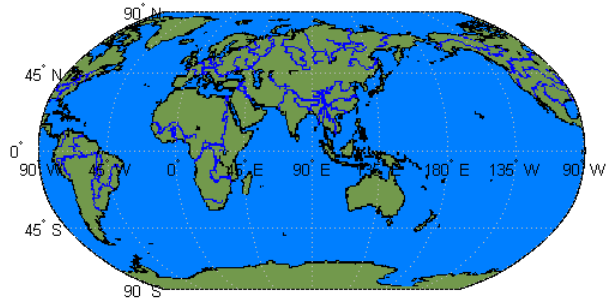
```
states = shaperead('usastatelo', 'UseGeoCoords', true);
lat = [states.Lat];
lon = [states.Lon];
[Z, R] = vec2mtx(lat, lon, 5, 'filled');
figure; worldmap(Z, R);
geoshow(Z, R, 'DisplayType', 'texturemap')
colormap(flag(3))
```



Example 2

Combine two separate calls to `vec2mtx` to create a 4-color raster map showing interior land areas, coastlines, oceans, and world rivers.

```
coast = load('coast.mat');
[Z, R] = vec2mtx(coast.lat, coast.long, ...
    1, [-90 90], [-90 270], 'filled');
rivers = shaperead('worldrivers.shp','UseGeoCoords',true);
A = vec2mtx([rivers.Lat], [rivers.Lon], Z, R);
Z(A == 1) = 3;
figure; worldmap(Z, R)
geoshow(Z, R, 'DisplayType', 'texturemap')
colormap([.45 .60 .30; 0 0 0; 0 0.5 1; 0 0 1])
```

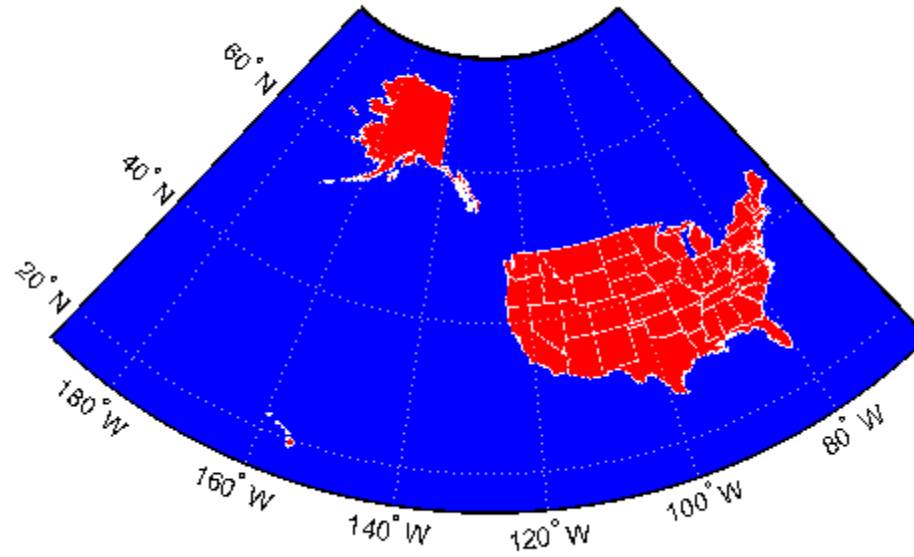


Example 3

This example illustrates the following syntax in the case where `R1` is a spatial referencing object:

```
[Z, R] = vec2mtx(lat, lon, Z1, R1)

% Import US state outlines.
states = shaperead('usastatelo', 'UseGeoCoords', true);
lat = [states.Lat];
lon = [states.Lon];

% Choose geographic limits.
latlim = [  15  75];
lonlim = [-190 -65];

% Specify a grid with 5 cells per degree.
density = 5;

% Compute raster size. (M and N both work out to be integers.)
M = density * diff(latlim);
N = density * diff(lonlim);

% Construct a spatialref.GeoRasterReference object.
R = georasterref('RasterSize', [M N], ...
    'ColumnsStartFrom', 'north', 'Latlim', latlim, ...
```

```
  'Lonlim', lonlim);

% Create a blank grid that is consistent with R in
% size -- vec2mtx requires a data grid as input.
Z = zeros(R.RasterSize);

% Overwrite Z with a new grid including state outlines
% and interiors.
Z = vec2mtx(lat, lon, Z, R, 'filled');

% Plot the georeferenced grid.
figure; worldmap(Z, R);
geoshow(Z, R, 'DisplayType', 'texturemap')
colormap(flag(3))
```



See Also

`imbedm`

Purpose

Direction angle in map plane from azimuth on ellipsoid

Syntax

```
th = vfwdtran(lat,lon,az)
th = vfwdtran(mstruct,lat,lon,az)
[th,len] = vfwdtran(...)
```

Description

`th = vfwdtran(lat,lon,az)` transforms the azimuth angle at specified latitude and longitude points on the sphere into the projection space. The map projection currently displayed is used to define the projection space. The input angles must be in the same units as specified by the current map projection. The inputs can be scalars or matrices of the equal size. The angle in the projection space is defined as positive counterclockwise from the *x*-axis.

`th = vfwdtran(mstruct,lat,lon,az)` uses the map projection defined by the input `mstruct` to compute the map projection.

`[th,len] = vfwdtran(...)` also returns the vector length in the projected coordinate system. A value of 1 indicates no scale distortion.

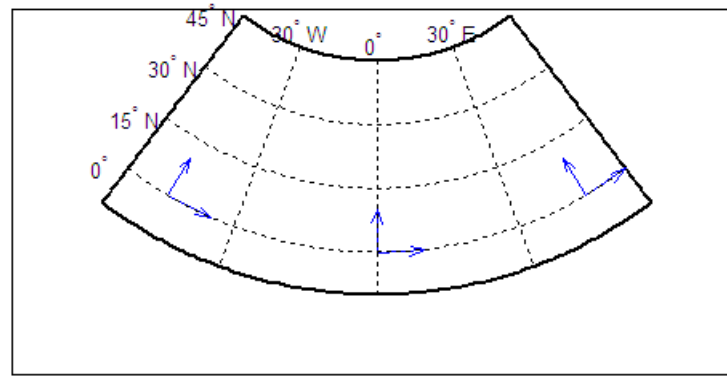
Background

The direction of north is easy to define on the three-dimensional sphere, but more difficult on a two-dimensional map. For cylindrical projections in the normal aspect, north is always in the positive *y*-direction. For conic projections, north can be to the left or right of the *y*-axis. This function transforms any azimuth angle on the sphere to the corresponding angle in the projected paper coordinates.

Examples

Sample calculations:

```
axesm('eqdconic','maplatlim',[-10 45],'maplonlim',[-55 55])
gridm; framem; mlabel; plabel
quiverm([0 0 0],[-45 0 45],[0 0 0],[10 10 10],0)
quiverm([0 0 0],[-45 0 45],[10 10 10],[0 0 0],0)
```




```
vfwdtran([0 0 0],[-45 0 45],[0 0 0])

ans =
       59.614            90       120.39

vfwdtran([0 0 0],[-45 0 45],[90 90 90])

ans =
      -30.385     0.0001931        30.386
```

Limitations

This transformation is limited to the region specified by the frame limits in the current map definition.

Tips

The geographic azimuth angle is measured clockwise from north. The projection space angle is measured counterclockwise from the *x*-axis.

This function uses a finite difference technique. The geographic coordinates are perturbed slightly in different directions and projected. A small amount of error is introduced by numerical computation of derivatives and the variation of map distortion parameters.

See Also

`vinvtran` | `mfwdtran` | `minvtran` | `defaultm`

Purpose

Areas visible from point on terrain elevation grid

Syntax

```
[vis,R] = viewshed(Z,R,lat1,lon1)
viewshed(Z,R,lat1,lon1,observerAltitude)
viewshed(Z,R,lat1,lon1,observerAltitude,targetAltitude)
viewshed(Z,R,lat1,lon1,observerAltitude,targetAltitude, ...
  observerAltitudeOption)
viewshed(Z,R,lat1,lon1,observerAltitude,targetAltitude, ...
  observerAltidueOption,targetAltitudeOption)
viewshed(Z,R,lat1,lon1,observerAltitude,targetAltitude, ...
  observerAltitudeOption,targetAltitudeOption,actualRadius)
viewshed(Z,R,lat1,lon1,observerAltitude,targetAltitude, ...
  observerAltitudeOption,targetAltitudeOption, ...
  actualRadius,effectiveRadius)
```

Description

`[vis,R] = viewshed(Z,R,lat1,lon1)` computes areas visible from a point on a digital elevation grid. `Z` is a regular data grid containing elevations in units of meters. The observer location is provided as scalar latitude and longitude in units of degrees. The visibility grid `vis` contains `1`s at the surface locations visible from the observer location, and `0`s where the line of sight is obscured by terrain. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to or from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls

along a meridian and each row falls along a parallel. Nearest-neighbor interpolation is used by default. NaN is returned for points outside the grid limits or for which `lat` or `lon` contain NaN. All angles are in units of degrees.

`viewshed(Z,R,lat1,lon1,observerAltitude)` places the observer at the specified altitude in meters above the surface. This is equivalent to putting the observer on a tower. If omitted, the observer is assumed to be on the surface.

`viewshed(Z,R,lat1,lon1,observerAltitude,targetAltitude)` checks for visibility of target points a specified distance above the terrain. This is equivalent to putting the target points on towers that do not obstruct the view. if omitted, the target points are assumed to be on the surface.

`viewshed(Z,R,lat1,lon1,observerAltitude,targetAltitude, ...`
`observerAltitudeOption)` controls whether the observer is at a relative or absolute altitude. If the `observerAltitudeOption` is `'AGL'`, then `observerAltitude` is in meters above ground level. If `observerAltitudeOption` is `'MSL'`, `observerAltitude` is interpreted as altitude above zero, or mean sea level. If omitted, `'AGL'` is assumed.

`viewshed(Z,R,lat1,lon1,observerAltitude,targetAltitude, ...`
`observerAltidueOption,targetAltitudeOption)` controls whether the target points are at a relative or absolute altitude. If the target altitude option is `'AGL'`, the `targetAltitude` is in meters above ground level. If `targetAltitudeOption` is `'MSL'`, `targetAltitude` is interpreted as altitude above zero, or mean sea level. If omitted, `'AGL'` is assumed.

`viewshed(Z,R,lat1,lon1,observerAltitude,targetAltitude, ...`
`observerAltitudeOption,targetAltitudeOption,actualRadius)` does the visibility calculation on a sphere with the specified radius. If omitted, the radius of the earth in meters is assumed. The altitudes, the elevations, and the radius should be in the same units. This calling form is most useful for computations on bodies other than the Earth.

`viewshed(Z,R,lat1,lon1,observerAltitude,targetAltitude, ...`
`observerAltitudeOption,targetAltitudeOption, ...`

`actualRadius,effectiveRadius)` assumes a larger radius for propagation of the line of sight. This can account for the curvature of the signal path due to refraction in the atmosphere. For example, radio propagation in the atmosphere is commonly treated as straight line propagation on a sphere with 4/3 the radius of the Earth. In that case the last two arguments would be `R_e` and `4/3*R_e`, where `R_e` is the radius of the earth. Use `Inf` for flat Earth `viewshed` calculations. The altitudes, the elevations, and the radii should be in the same units.

Tips

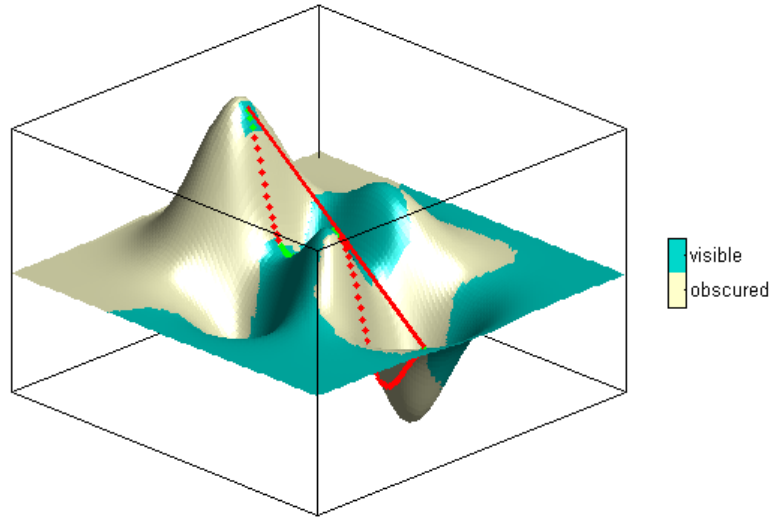
The observer should be located within the latitude-longitude limits of the elevation grid. If the observer is located outside the grid, there is insufficient information to calculate a viewshed. In this case `viewshed` issues a warning and sets all elements of `vis` to zero.

Examples

Compute visibility for a point on the peaks map. Add the detailed information for the line of sight calculation between two points from `los2`.

```
Z = 500*peaks(100);
refvec = [ 1000 0 0];
[lat1,lon1,lat2,lon2]=deal(-0.027,0.05,-0.093,0.042);

[visgrid,visleg] = viewshed(Z,refvec,lat1,lon1,100);
[vis,visprofile,dist,zi,lattrk,lontrk] ...
   = los2(Z,refvec,lat1,lon1,lat2,lon2,100);

axesm('globe','geoid',earthRadius('meters'))
meshm(visgrid,visleg,size(Z),Z); axis tight
camposm(-10,-10,1e6); camupm(0,0)
colormap(flipud(summer(2))); brighten(0.75);
shading interp; camlight
h = lcolorbar({'obscured','visible'});
set(h,'Position',[.875 .45 .02 .1])

plot3m(lattrk([1;end]),lontrk([1; end]), ...
   zi([1; end])+[100; 0],'r','linewidth',2)
plotm(lattrk(~visprofile),lontrk(~visprofile), ...
```

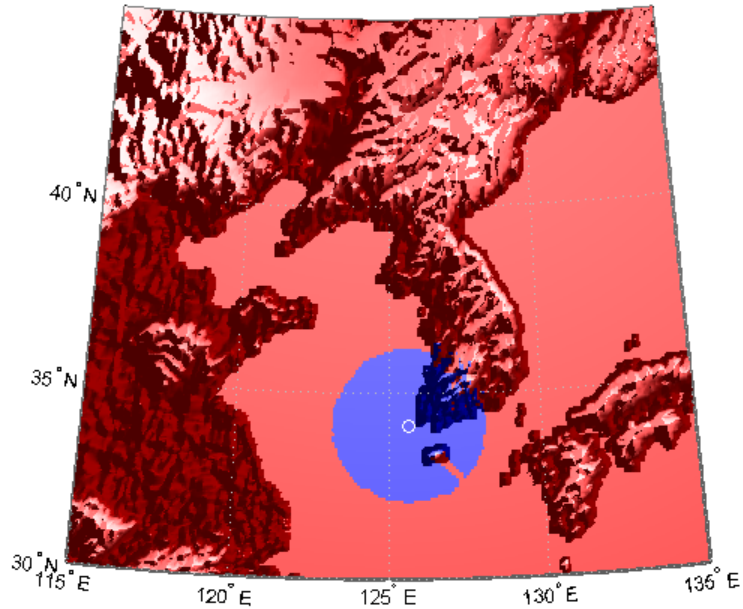
```
   zi(~visprofile),'r.','markersize',10)
plotm(lattrk(visprofile),lontrk(visprofile), ...
   zi(visprofile),'g.','markersize',10)
```



Compute the surface areas visible by radar from an aircraft 3000 meters above the Yellow Sea. Assume that radio wave propagation in the atmosphere can be modeled as straight lines on a 4/3 radius Earth. Display the visible areas as blue and the obscured areas as red. Drape the visibility colors on an elevation map, and use lighting to bring out the surface topography. The aircraft's radar can see out a certain radius on the surface of the ocean, but some ocean areas are shadowed by the island of Jeju-Do. Also some mountain valleys closer than the ocean horizon are obscured, while some mountain tops further away are visible.

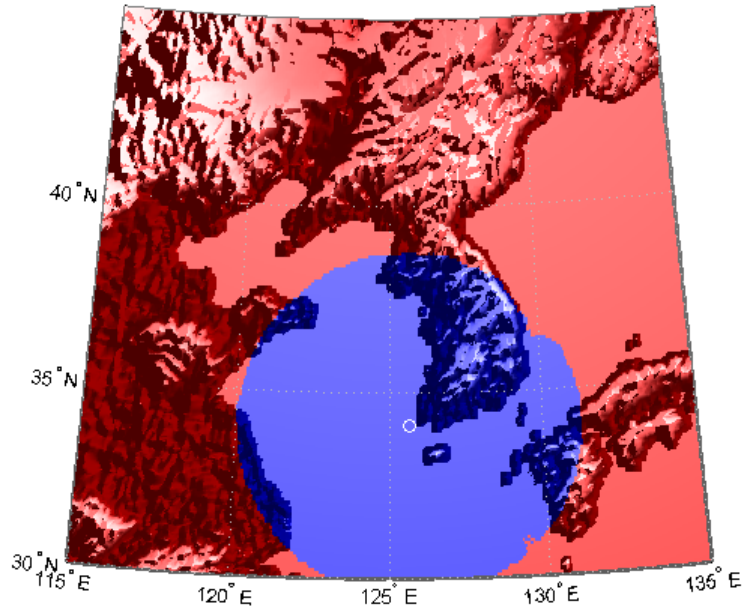
```
load korea
map(map<0) = -1;
```

```
figure
worldmap(map,refvec)
da = daspect;
pba = pbaspect;
da(3) = 7.5*pba(3)/da(3);
daspect(da);
demcmap(map)
camlight(90,5);
camlight(0,5);
lighting phong
material([0.25 0.8 0])
lat = 34.0931; lon = 125.6578;
altobs = 3000; alttarg = 0;
plotm(lat,lon,'wo')
Re = earthRadius('meters');
[vmap,vmapl] = viewshed( ...
   map,refvec,lat,lon,altobs,alttarg, ...
   'MSL','AGL',Re,4/3*Re);
meshm(vmap,vmapl,size(map),map)
caxis auto; colormap([1 0 0; 0 0 1])
lighting phong; material metal
axis off
```



Over what area can the radar plane flying at an altitude of 3000 meters have line-of-sight to other aircraft flying at 5000 meters? Now the area is much larger. Some edges of the area are reduced by shadowing from Jeju-Do and the mountains on the Korean peninsula.

```
[vmap,vmapl] = viewshed(map,refvec,lat,lon,3000,5000, ...
                'MSL','MSL',Re,4/3*Re);
clmo surface
meshm(vmap,vmapl,size(map),map)
material metal
lighting phong
```



See Also

`los2`

vinvtran

Purpose

Azimuth on ellipsoid from direction angle in map plane

Syntax

```
az = vinvtran(x,y,th)
az = vinvtran(mstruct,x,y,th)
[az,len] = vinvtran(...)
```

Description

`az = vinvtran(x,y,th)` transforms an angle in the projection space at the point specified by `x` and `y` into an azimuth angle in geographic coordinates. The map projection currently displayed is used to define the projection space. The input angles must be in the same units as specified by the current map projection. The inputs can be scalars or matrices of equal size. The angle in the projection space angle `th` is defined as positive counterclockwise from the *x*-axis.

`az = vinvtran(mstruct,x,y,th)` uses the map projection defined by the input `struct` to compute the map projection.

`[az,len] = vinvtran(...)` also returns the vector length in the geographic coordinate system. A value of 1 indicates no scale distortion for that angle.

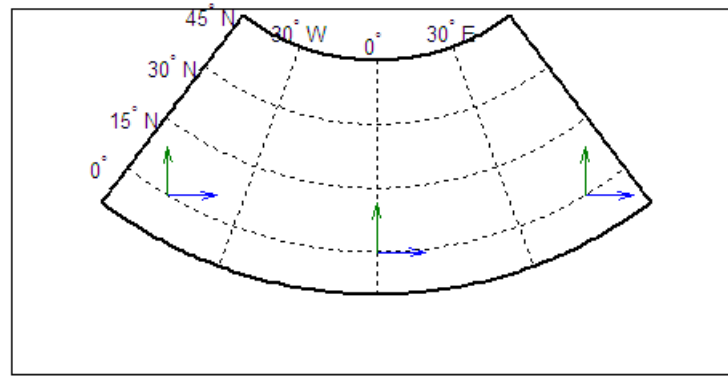
Background

While vectors along the *y*-axis always point to north in a cylindrical projection in the normal aspect, they can point east or west of north on conics, azimuthals, and other projections. This function computes the geographic azimuth for angles in the projected space.

Examples

Sample calculations:

```
axesm('eqdconic','maplatlim',[-10 45],'maplonlim',[-55 55])
gridm; framem; mlabel; plabel
[x,y] = mfwdtran([0 0 0],[-45 0 45]);
quiver(x,y,[ .2 .2 .2],[0 0 0],0)
quiver(x,y,[0 0 0],[ .2 .2 .2],0)
```




```
vinvtran(x,y,[ 0 0 0])

ans =
       57.345       90.338       124.98

vinvtran(x,y,[ 90 90 90])

ans =
       331.99            0       28.008
```

Limitations

This transformation is limited to the region specified by the frame limits in the current map definition.

Tips

The geographic azimuth angle is measured clockwise from north. The projection space angle is measured counterclockwise from the *x*-axis.

This function uses a finite difference technique. The geographic coordinates are perturbed slightly in different directions and projected. A small amount of error is introduced by numerical computation of derivatives and the variation of map distortion parameters.

See Also

`vfwdtran` | `mfwdtran` | `minvtran` | `defaultm`

vmap0data

Purpose

Read selected data from Vector Map Level 0

Syntax

```
struct = vmap0data(library,latlim,lonlim,theme,topolevel)
struct = vmap0data(devicename,library, ...)
[struct1, struct2, ...] =   vmap0data(...,{topolevel1,
   topolevel2,...})
```

Description

`struct = vmap0data(library,latlim,lonlim,theme,topolevel)` reads the data for the specified theme and topology level directly from the VMAP0 CD-ROM. There are four CDs, one for each of the libraries: `'NOAMER'` (North America), `'SASAUS'` (Southern Asia and Australia), `'EURNASIA'` (Europe and Northern Asia), and `'SOAMAFR'` (South America and Africa). The desired *`theme`* is specified by a two-letter code string. A list of valid codes is displayed when an invalid code, such as `'?'`, is entered. *`topolevel`* defines the type of data returned. It is a string containing `'patch'`, `'line'`, `'point'`, or `'text'`. The region of interest can be given as a point latitude and longitude or as a region with two-element vectors of latitude and longitude limits. The units of latitude and longitude are degrees. The data covering the requested region is returned, but will include data extending to the edges of the tiles. The result is returned as a Mapping Toolbox Version 1 display structure.

`struct = vmap0data(devicename,library, ...)` specifies the logical device name of the CD-ROM for computers that do not automatically name the mounted disk.

`[struct1, struct2, ...] = vmap0data(...,{topolevel1,topolevel2,...})` reads several topology levels. The levels must be specified as a cell array with the entries `'patch'`, `'line'`, `'point'`, or `'text'`. Entering `{'all'}` for the topology level argument is equivalent to `{'patch', 'line', 'point', 'text'}`. Upon output, the data structures are returned in the output arguments by topology level in the same order as they were requested.

Background

The Vector Map (VMAP) Level 0 database represents the third edition of the *Digital Chart of the World*. The second edition was a limited

release item published in 1995. The product is dual named to show its lineage to the original DCW, published in 1992, while positioning the revised product within a broader emerging family of VMAP products. VMAP Level 0 is a comprehensive 1:1,000,000 scale vector base map of the world. It consists of cartographic, attribute, and textual data stored on compact disc read-only memory (CD-ROM). The primary source for the database is the Operational Navigation Chart (ONC) series of the U. S. National Geospatial Intelligence Agency (NGA), formerly the National Imagery and Mapping Agency (NIMA), and before that, the Defense Mapping Agency (DMA). This is the largest scale unclassified map series in existence that provides consistent, continuous global coverage of essential base map features. The database contains more than 1,900 MB of vector data and is organized into 10 thematic layers. The data includes major road and rail networks, major hydrologic drainage systems, major utility networks (cross-country pipelines and communication lines), all major airports, elevation contours (1000 foot (ft), with 500 ft and 250 ft supplemental contours), coastlines, international boundaries, and populated places. The database can be accessed directly from the four optical CD-ROMs that store the database or can be transferred to magnetic media.

Tips

Data are returned as Mapping Toolbox display structures, which you can then update to geographic data structures. For information about display structure format, see “Version 1 Display Structures” on page 3-177 in the reference page for `displaym`. The `updategeostruct` function performs such conversions.

Latitudes and longitudes use WGS84 as a horizontal datum. Elevations and depths are in meters above mean sea level.

Some VMAP0 themes do not contain all topology levels. In those cases, empty matrices are returned.

Patches are broken at the tile boundaries. Setting the `EdgeColor` to `'none'` and plotting the lines gives the map a normal appearance.

The major differences between VMAP0 and the DCW are the elimination of the gazette layer, addition of bathymetric data, and updated political boundaries.

Vector Map Level 0, created in the 1990s, is still probably the most detailed global database of vector map data available to the public. VMAP0 CD-ROMs are available from through the U.S. Geological Survey (USGS):

USGS Information Services (Map and Book Sales)
Box 25286
Denver Federal Center
Denver, CO 80225
Telephone: (303) 202-4700
Fax: (303) 202-4693

Note For details on locating map data for download over the Internet, see the following documentation at the MathWorks Web site: http://www.mathworks.com/help/map/finding-geospatial-data.html .

Examples

The *devicename* is platform dependent. On an MS-DOS based operating system it would be something like `'d:'`, depending on the logical device code assigned to the CD-ROM drive. On a UNIX operating system, the CD-ROM might be mounted as `'\cdrom'`, `'\CDROM'`, `'\cdrom1'`, or something similar. Check your computer's documentation for the right *devicename*.

```
s = vmap0data(devicename,'NOAMER',41,-69,'?','patch');

??? Error using ==> vmap0data
Theme not present in library NOAMER

Valid theme identifiers are:
libref : Library Reference
tileref: Tile Reference
bnd    : Boundaries
dq     : Data Quality
elev   : Elevation
hydro  : Hydrography
```

```
ind    : Industry
phys   : Physiography
pop    : Population
trans  : Transportation
util   : Utilities
veg    : Vegetation

BNDpatch = vmap0data(devicename,'NOAMER',...
                     [41 44],[-72 -69],'bnd','patch')
BNDpatch =
1x169 struct array with fields:
    type
    otherproperty
    altitude
    lat
    long
    tag
```

Here are other examples:

```
[TRtext,TRline] = vmap0data(devicename,'SASAUS',...
     [-48 -34],[164 180],'trans',{'text','line'});

[BNDpatch,BNDline,BNDpoint,BNDtext] = vmap0data(devicename,...
     'EURNASIA',-48 ,164,'bnd',{'all'});
```

See Also

vmap0read | vmap0rhead | geoshow | extractm | mlayers | updategeostruct

vmap0read

Purpose

Read Vector Map Level 0 file

Syntax

```
vmap0read
vmap0read(filepath,filename)
vmap0read(filepath,filename,recordIDs)
vmap0read(filepath,filename,recordIDs,field,varlen)
struc = vmap0read(...)
[struc,field] = vmap0read(...)
[struc,field,varlen] = vmap0read(...)
[struc,field,varlen,description] = vmap0read(...)
[struc,field,varlen,description,
   narrativefield] = vmap0read(...)
```

Description

`vmap0read` reads a VMAP0 file. The user selects the file interactively.

`vmap0read(filepath,filename)` reads the specified file. The combination [*filepath filename*] must form a valid complete filename.

`vmap0read(filepath,filename,recordIDs)` reads selected records or fields from the file. If `recordIDs` is a scalar or a vector of integers, the function returns the selected records. If `recordIDs` is a cell array of integers, all records of the associated fields are returned. `vmap0read(filepath,filename,recordIDs,field,varlen)`

uses previously read field and variable-length record information to skip parsing the file header (see below).

`struc = vmap0read(...)` returns the file contents in a structure.

`[struc,field] = vmap0read(...)` returns the file contents and a structure describing the format of the file.

`[struc,field,varlen] = vmap0read(...)` also returns a vector describing which fields have variable-length records.

`[struc,field,varlen,description] = vmap0read(...)` also returns a string describing the contents of the file.

`[struc,field,varlen,description,narrativefield] = vmap0read(...)` also returns the name of the narrative file for the current file.

Background

The Vector Map Level 0 (VMAP0) uses binary files in a variety of formats. This function determines the format of the file and returns the contents in a structure. The field names of this structure are the same as the field names in the VMAP0 file.

Tips

This function reads all VMAP0 files except index files (files with names ending in `'X'`), thematic index files (files with names ending in `'TI'`), and spatial index files (files with names ending in `'SI'`).

File separators are platform dependent. The *`filepath`* input must use appropriate file separators, which you can determine using the MATLAB `filesep` function.

Examples

The following examples use the UNIX directory system and file separators for the pathname:

```
s = vmap0read('VMAP/VMAPLV0/NOAMER/','GRT')

s =
                  id: 1
           data_type: 'GEO'
               units: 'M'
      ellipsoid_name: 'WGS 84'
    ellipsoid_detail: 'A=6378137 B=6356752 Meters'
     vert_datum_name: 'MEAN SEA LEVEL'
     vert_datum_code: 'O15'
    sound_datum_name: 'N/A'
    sound_datum_code: 'N/A'
      geo_datum_name: 'WGS 84'
      geo_datum_code: 'WGE'
     projection_name: 'Dec. Deg. (unproj.)'

s = vmap0read('VMAP/VMAPLV0/NOAMER/TRANS/','INT.VDT')

s =
34x1 struct array with fields:
    id
```

```
    table
    attribute
    value
    description

s(1)

ans =
            id: 1
         table: 'aerofacp.pft'
     attribute: 'use'
         value: 8
    description: 'Military'
s = vmap0read('VMAP/VMAPLV0/NOAMER/TRANS/','AEROFACP.PFT',1)

s =
         id: 1
     f_code: 'GB005'
        iko: 'BGTL'
        nam: 'THULE AIR BASE'
        na3: 'GL52085'
        use: 8
        zv3: 77
    tile_id: 10
     end_id: 1

s = vmap0read('VMAP/VMAPLV0/NOAMER/TRANS/','AEROFACP.PFT',{1,2})

s =
1x4424 struct array with fields:
    id
    f_code
```

See Also

vmap0data | vmap0rhead

Purpose

Read Vector Map Level 0 file headers

Syntax

```
vmap0rhead
vmap0rhead(filepath,filename)
vmap0rhead(filepath,filename,fid)
vmap0rhead(...),
str = vmap0rhead(...)
```

Description

`vmap0rhead` allows the user to select the header file interactively.

`vmap0rhead(filepath,filename)` reads from the specified file. The combination [*filepath filename*] must form a valid complete *filename*.

`vmap0rhead(filepath,filename,fid)` reads from the already open file associated with `fid`.

`vmap0rhead(...),` with no output arguments, displays the formatted header information on the screen.

`str = vmap0rhead(...)` returns a string containing the VMAP0 header.

Background

The Vector Map Level 0 (VMAP0) uses header strings in most files to document the contents and format of that file. This function reads the header string and displays a formatted version in the Command Window, or returns it as a string.

Tips

This function reads all VMAP0 files except index files (files with names ending in `'X'`), thematic index files (files with names ending in `'TI'`) and spatial index files (files with names ending in `'SI'`).

File separators are platform dependent. The *filepath* input must use appropriate file separators, which you can determine using the MATLAB `filesep` function.

Examples

The following example uses UNIX file separators and pathname:

```
s = vmap0rhead('VMAP/VMAPLV0/NOAMER/','GRT')
```

```
s =
L;Geographic Reference Table;-;id=I,1,P,Row
Identifier,-,-,-,:data_type=T,3,N,Data
Type,-,-,-,:units=T,3,N,Units of Measure Code for
Library,-,-,-,:ellipsoid_name=T,15,N,Ellipsoid,-,-,-,:ellipsoid
_detail=T,50,N,Ellipsoid
Details,-,-,-,:vert_datum_name=T,15,N,Datum Vertical
Reference,-,-,-,:vert_datum_code=T,3,N,Vertical Datum
Code,-,-,-,:sound_datum_name=T,15,N,Sounding
Datum,-,-,-,:sound_datum_code=T,3,N,Sounding Datum
Code,-,-,-,:geo_datum_name=T,15,N,Datum Geodetic
Name,-,-,-,:geo_datum_code=T,3,N,Datum Geodetic
Code,-,-,-,:projection_name=T,20,N,Projection Name,-,-,-,:;

vmap0rhead('VMAP/VMAPLV0/NOAMER/TRANS/','AEROFACP.PFT')
L
Airport Point Feature Table
aerofacp.doc
id=I,1,P,Row Identifier,-,-,-,
f_code=T,5,N,FACC Feature Code,char.vdt,-,-,
iko=T,4,N,ICAO Designator,char.vdt,-,-,
nam=T,*,N,Name,char.vdt,-,-,
na3=T,*,N,Name,char.vdt,-,-,
use=S,1,N,Usage,int.vdt,-,-,
zv3=S,1,N,Airfield/Aerodrome Elevation (meters),int.vdt,-,-,
tile_id=S,1,N,Tile Reference ID,-,tile1_id.pti,-,
end_id=I,1,N,Entity Node Primitive ID,-,end1_id.pti,-,
```

See Also

vmap0data | vmap0read

Purpose

Web map server object

Description

A `WebMapServer` handle object represents a Web Map Service (WMS) and acts as a proxy to a WMS server. The `WebMapServer` handle object resides physically on the client side. The object can access the capabilities document on the WMS server and perform requests to obtain maps. It supports multiple WMS versions and negotiates with the server automatically to use the highest known version that the server can support.

Construction

`server = WebMapServer(serverURL)` constructs a `WebMapServer` object from the `serverURL` string parameter. The `serverURL` string parameter must include the protocol `'http://'` or `'https://'`. `WebMapServer` automatically communicates to the server defined by the `serverURL` using the highest known version that the server can support. `serverURL` can contain additional WMS keywords.

Properties

Timeout

Indicates the number of milliseconds before a server times out.

Data Type: `double`

Default: 0 (Indicates that the `WebMapServer` handle object ignores the time-out mechanism.)

EnableCache

Indicates if the `WebMapServer` handle object allows caching. If `true`, the `WebMapServer` handle object caches the `WMSCapabilites` object, which is returned when you use the `getCapabilities` method. The cache expires if the `AccessDate` property of the cached `WMSCapabilities` object is not the current day.

Data Type: logical

Default: `true`

ServerURL

Indicates the URL of the server.

Data Type: string

RequestURL

Indicates the URL of the last request to the server. `RequestURL` specifies a request for either the XML capabilities document or a map. You can insert the `RequestURL` into a browser.

Data Type: string

Methods

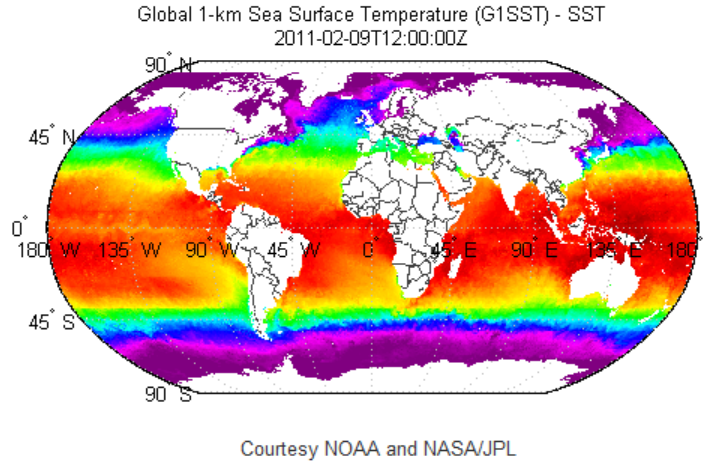
getCapabilities	Get capabilities document from server
getMap	Get raster map from server
updateLayers	Update layer properties

Examples

Construct a `WebMapServer` object that communicates with one of the Environmental Research Division's Data Access Program (ERDDAP) WMS servers hosted by NOAA and obtains its capabilities document. Search for a server that provides daily, global sea surface temperature (`sst`) data produced by the Jet Propulsion Laboratory's Regional Ocean Modeling System (JPL ROMS) group.

```
layers = wmsfind('coastwatch*jpl*sst', 'SearchField', 'serverurl');
serverURL = layers(1).ServerURL;
server = WebMapServer(serverURL);
capabilities = server.getCapabilities();

% Obtain and view the data from the server.
% Show the boundaries of the nations and
% the global SST data.
nations = capabilities.Layer.refine('nations');
sst = capabilities.Layer.refine('sst');
sst = sst(1);
```

```
request = WMSMapRequest([sst nations], server);
A = server.getMap(request.RequestURL);
R = request.RasterRef;
figure
worldmap(A, R)
geoshow(A, R)
title({sst.LayerTitle, sst.Details.Dimension.Default})
```



See Also

WMSCapabilities | wmsfind | wmsinfo | WMSMapRequest | wmsread | wmsupdate

WebMapServer.getCapabilities

Purpose

Get capabilities document from server

Syntax

```
capabilities = server.getCapabilities()
```

Description

`capabilities = server.getCapabilities()` retrieves the capabilities document from the server as a `WMSCapabilities` object and updates the `RequestURL` property.

Tips

The `getCapabilities` method accesses the Internet to retrieve the document. Periodically, the WMS server is unavailable. Retrieving the document can take several minutes.

Examples

Retrieve the capabilities document from the NASA SVS Image Server:

```
nasa = wmsfind('NASA SVS Image', 'SearchField', 'servertitle');
serverURL = nasa(1).ServerURL;
server = WebMapServer(serverURL);
capabilities = server.getCapabilities;
```

Purpose

Get raster map from server

Syntax

```
A = server.getMap(mapRequestURL)
```

Description

`A = server.getMap(mapRequestURL)` dynamically renders and retrieves a color or grayscale, geographically referenced, raster map from the server and stores it in `A`. Parameters in the URL, `mapRequestURL`, define the map. The `getMap` method also updates the `WMSMapRequest.RequestURL` property `mapRequestURL`.

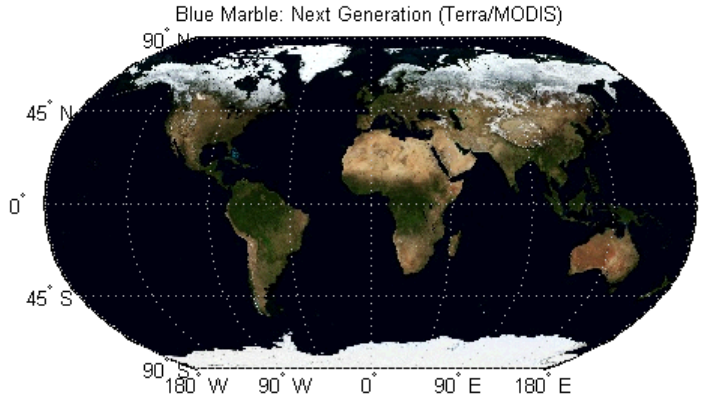
Tips

`getMap` accesses the Internet to retrieve the map. Periodically, the WMS server is unavailable. Retrieving the map can take several minutes.

Examples

Retrieve a map of the Blue Marble global mosaic layer from the NASA Earth Observations WMS server:

```
neowms = wmsfind('neowms', 'SearchField', 'serverurl');
layer = neowms.refine('bluemarbleng', ...
   'MatchType', 'exact');
server = WebMapServer(layer.ServerURL);
mapRequest = WMSMapRequest(layer, server);
A = server.getMap(mapRequest.RequestURL);
R = mapRequest.RasterRef;
figure
worldmap world
geoshow(A, R)
setm(gca,'MLabelParallel',-90,'MLabelLocation',90)
title(layer.LayerTitle)
```



Courtesy NASA Earth Observations

Purpose

Update layer properties

Syntax

```
[updatedLayer, index] = server.updateLayers(layer)
```

Description

`[updatedLayer, index] = server.updateLayers(layer)` returns a `WMSLayer` array with properties updated with values from the server. The `WMSLayer` array `Layer` must contain only one unique `ServerURL`. The `updateLayers` method removes layers no longer available on the server. The logical array `index` contains `true` for each available layer, such that `updatedLayers` has the same size as `layer(index)`.

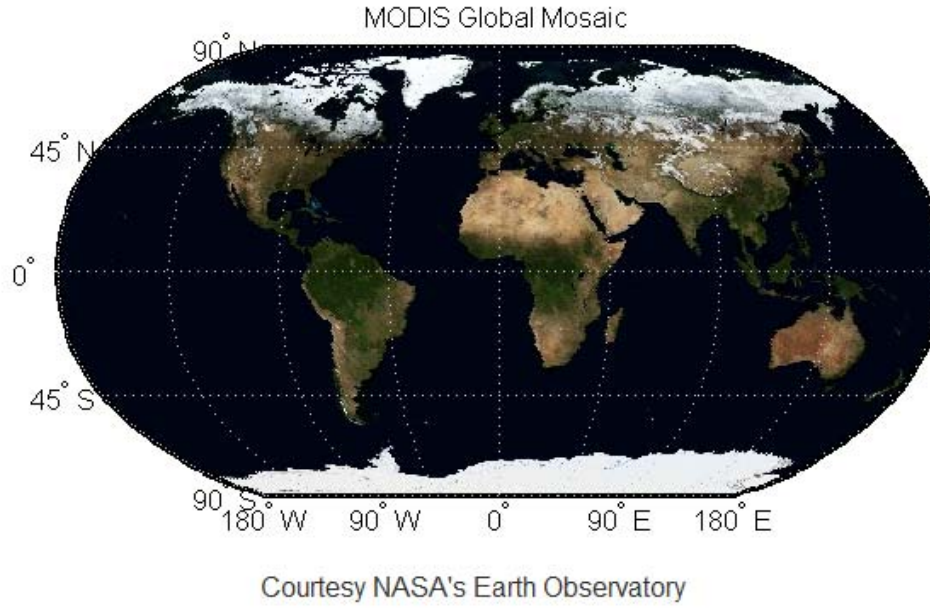
The `updateLayers` method accesses the Internet to update the properties. Occasionally, a WMS server is unavailable, or several minutes elapse before the properties are updated.

Examples

Update the properties of a MODIS global mosaic layer obtained from the NASA Earth Observations WMS server.

```
modis = wmsfind('modis');
modis = modis.refine('bluemarbleng');
modis = modis(1);

% Create a WebMapServer object.
server = WebMapServer(modis.ServerURL);

% Update the properties of the modis layer.
updatedLayer = server.updateLayers(modis);

% View the metadata of the layer.
metadata = urlread(updatedLayer.Details.MetadataURL);
disp(metadata)

% Obtain and display the map.
mapRequest = WMSMapRequest(updatedLayer, server);
A = server.getMap(mapRequest.RequestURL);
R = mapRequest.RasterRef;
figure
```

```
worldmap world
geoshow(A, R)
setm(gca,'MLabelParallel',-90,'MLabelLocation',90)
title('MODIS Global Mosaic')
```



Update the properties of layers from multiple servers. Find layers from USGS servers with the name `geology` in the server URL.

```
usgs = wmsfind('usgs.gov*geology', 'SearchField', 'serverurl');
```

Find the layers for an individual server USGS layers, update their properties, and append them to the updatedLayers array.

```
serverURLs = servers(usgs);
updatedLayers = [];
fprintf('Updating layer properties from %d servers.\n', ...
    length(serverURLs));

for k=1:numel(serverURLs)
    serverURL = serverURLs{k};
    serverLayers = refine(usgs, serverURL, ...
        'SearchField', 'serverurl', 'MatchType', 'exact');
    fprintf('Updating properties from server %d:\n%s\n', ...
        k, serverURL);
    wms = WebMapServer(serverURL);
    try
        layers = updateLayers(wms, serverLayers);
        % Grow using concatenation because layers can have
        % any length ranging from 0 to numel(serverLayers).
        updatedLayers = [updatedLayers; layers];
    catch e
        fprintf('Server %s is not available.\n', serverURL);
        fprintf('Error message is %s\n', e.message)
    end
end
```

westof

Purpose

Wrap longitudes to values west of specified meridian

Note The `westof` function is obsolete and will be removed in a future release of the toolbox. Replace it with the following calls, which are also more efficient:

```
westof(lon,meridian,'degrees') ==> meridian-mod(meridian-lon,360)

westof(lon,meridian,'radians') ==> meridian-mod(meridian-lon,2*pi)
```

Syntax

```
lonWrapped = westof(lon,meridian)
lonWrapped = westof(lon,meridian,angleunits)
```

Description

`lonWrapped = westof(lon,meridian)` wraps angles in `lon` to values in the interval `(meridian-360 meridian]`. `lon` is a scalar longitude or vector of longitude values. All inputs and outputs are in degrees.

`lonWrapped = westof(lon,meridian,angleunits)` specifies the input and output units with the string *`angleunits`*. *`angleunits`* can be either `'degrees'` or `'radians'`. It may be abbreviated and is case-insensitive. If *`angleunits`* is `'radians'`, the input is wrapped to the interval `(meridian-2*pi meridian]`.

Purpose

Reference ellipsoid for World Geodetic System 1984

Syntax

```
E = wgs84Ellipsoid
E = wgs84Ellipsoid(lengthUnit)
```

Description

`E = wgs84Ellipsoid` returns a `referenceEllipsoid` object representing the World Geodetic System of 1984 (WGS 84) reference ellipsoid. The semimajor axis and semiminor axis are expressed in meters.

`E = wgs84Ellipsoid(lengthUnit)` returns a WGS 84 reference ellipsoid object in which the semimajor axis and semiminor axis are expressed in the specified unit, `lengthUnit`.

Input Arguments

lengthUnit

Any string accepted by the `validateLengthUnit` function.

DataType: String.

Output Arguments

E

`referenceEllipsoid` object for WGS 84.

Examples

Creating a WGS 84 reference ellipsoid

Create a reference ellipsoid for WGS 84.

```
wgs84InMeters = wgs84Ellipsoid
wgs84InKilometers = wgs84Ellipsoid('km')
```

```
wgs84InMeters =

  referenceEllipsoid

  Properties:
                Code: 7030
                Name: 'World Geodetic System 1984'
          LengthUnit: 'meter'
```

```
            SemimajorAxis: 6378137
            SemiminorAxis: 6356752.31424518
        InverseFlattening: 298.257223563
             Eccentricity: 0.0818191908426215


wgs84InKilometers =

  referenceEllipsoid

  Properties:
                    Code: 7030
                    Name: 'World Geodetic System 1984'
              LengthUnit: 'kilometer'
            SemimajorAxis: 6378.137
            SemiminorAxis: 6356.75231424518
        InverseFlattening: 298.257223563
             Eccentricity: 0.0818191908426215
```

See Also `referenceEllipsoid` |

Purpose

Web Map Service capabilities object

Description

A `WMSCapabilities` object represents a Web Map Service (WMS) capabilities document obtained from a WMS server.

Construction

`capabilities = WMSCapabilites(ServerURL, capabilitiesResponse)` constructs a `WMSCapabilities` object from the input string parameters. The `ServerURL` string, a WMS server URL, includes the protocol `'http://'` or `'https://'`. The `capabilitiesResponse` string contains XML elements that describe the capabilities of the `ServerURL` WMS server.

Properties

ServerTitle

Title of server

Data Type: string

ServerURL

URL of server

Data Type: string

ServiceName

Name of Web map service

Data Type: string

Version

WMS version specification

Data Type: string

Abstract

Information about server

Data Type: string

OnlineResource

Online information about server

Data Type: string (URL)

ContactInformation

Contact information for an individual or an organization, including an email address, if provided

Data Type: structure

ContactInformation Structure Array

Field Name	Data Type	Field Content
`Person`	String	Name of individual
`Organization`	String	Name of organization
`Email`	String	Email address

AccessConstraints

Constraints inherent in accessing the server, such as server load limits

Data Type: string

Fees

Types of fees associated with accessing server

Data Type: string

KeywordList

Descriptive keywords of the server

Data Type: cell array of strings

ImageFormats

Image formats supported by server

Data Type: cell array of strings

LayerNames

Layer names provided by server

Data Type: cell array of strings

Layer

Information about layers on WMS server. See the `WMSCapabilities.Layer` reference page for more information.

Data Type: `WMSLayer` array

AccessDate

Date of request to server

Data Type: string

Methods

disp	Display properties

Examples

Construct a `WMSCapabilities` object from the contents of a downloaded capabilities file from the NASA SVS Image Server:

```
nasa = wmsfind('NASA SVS Image', 'SearchField', 'servertitle');
serverURL = nasa(1).ServerURL;
server = WebMapServer(serverURL);
capabilities = server.getCapabilities;
filename = 'capabilities.xml';
urlwrite(server.RequestURL, filename);

fid = fopen(filename, 'r');
capabilitiesResponse = fread(fid, 'uint8=>char');
fclose(fid);
capabilities = WMSCapabilities(serverURL, capabilitiesResponse);
```

See Also

`WebMapServer` | `wmsinfo` | `WMSLayer`

WMSCapabilities.disp

Purpose

Display properties

Syntax

```
capabilities.disp()
```

Description

`capabilities.disp()` displays the class properties. The method removes hyperlinks and expands string and cell array properties.

Purpose

Layer information

Description

A `WMSLayer` array containing information about the layers available on a WMS server.

Property Name	Data Type	Property Content
`ServerTitle`	String	Descriptive title of server
`ServerURL`	String	URL of server
`LayerTitle`	String	Descriptive title of layer
`LayerName`	String	Name of layer
`Latlim`	Double array	Southern and northern latitude limits of layer
`Lonlim`	Double array	Western and eastern longitude limits of layer
`Abstract`	String	Information about layer
`CoordRefSysCodes`	Cell array	Codes of available coordinate reference systems
`Details`	Structure	Detailed information about layer

wmsfind

Purpose

Search local database for Web map servers and layers

Syntax

```
layers = wmsfind(querystr)
layers = wmsfind(querystr, Name,Value, ...)
```

Description

`layers = wmsfind(querystr)` searches the `LayerTitle` and `LayerName` fields of the installed Web Map Service (WMS) Database for partial matches with the string *`querystr`*. WMS servers, by definition, produce maps of spatially referenced raster data. You can search for specific types of data, known as layers, such as temperature or elevation. The string *`querystr`* can contain the wildcard character `'*'`. The array returned by `wmsfind`, `layers`, contains one element for each layer whose name or title partially matches *`querystr`*. Each element is a `WMSLayer` object.

The installed WMS Database contains a subset of the `WMSLayer` properties (`ServerTitle`, `ServerURL`, `LayerTitle`, `LayerName`, `Latlim`, and `Lonlim`). The information found in the database is static and is not automatically updated; it was validated at the time of the software release.

`layers = wmsfind(querystr, Name,Value, ...)` modifies the search of the WMS database based on the values of the parameters. You can abbreviate parameter names, and case does not matter.

Tips

- The WMS Database does not store content for the properties `'Abstract'`, `'CoordRefSysCodes'`, and `'Details'`. Therefore, you cannot use `wmsfind` to search these properties. Populate these fields by using the `wmsupdate` function. This function updates these properties by downloading information from the server. The `WMSLayer.disp` method does not automatically display these unpopulated properties. Set the `WMSLayer.disp` `'Properties'` parameter to `'all'` to view. After you have viewed the information available from `wmsupdate`, if you still want to know more about the WMS server, use the function `wmsinfo` with the specific server URL.

Input Arguments

querystr

Specifies the search string, such as `'temperature'`

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

IgnoreCase

Logical that specifies whether to ignore case when performing string comparisons. Possible values are `true` or `false`.

Default: `true`

Latlim

Two-element vector of latitude specifying the latitudinal limits of the search in the form `[southern_limit northern_limit]` or scalar value representing the latitude of a single point. All angles are in units of degrees.

If provided and not empty, a given layer appears in the results only if its limits fully contain the specified `'Latlim'` limits. Partial overlap does not result in a match.

Lonlim

Two-element vector of longitude specifying the longitudinal limits of the search in the form `[western_limit eastern_limit]` or scalar value representing the longitude of a single point. All angles are in units of degrees.

If provided and not empty, a given layer appears in the results only if its limits contain the specified `'Lonlim'` limits. Partial overlap does not result in a match.

MatchType

String with value `'partial'` or `'exact'`. For a partial string match, specify `'partial'` for the `'MatchType'`. For an exact match, specify `'exact'`. If `'MatchType'` is `'exact'` and `querystr` is `'*'`, a match occurs when the search field matches the character `'*'`.

Default: `'partial'`

SearchFields

String or cell array of strings. Valid strings are `'layer'`, `'layertitle'`, `'layername'`, `'server'`, `'serverurl'`, `'servertitle'`, or `'any'`.

The function searches the entries in the `'SearchFields'` of the WMS database for a partial match with `querystr`. If you specify `'layer'`, then `wmsfind` searches both the `'layertitle'` and `'layername'` fields. If you specify `'server'`, then `wmsfind` searches both the `'serverurl'` and `'servertitle'` fields. The function returns layer information if any supplied `'SearchFields'` match.

Default: {`'layer'`}

Output Arguments

layers

Array that contains one element for each layer whose name or title partially matches *`querystr`*. Each element is a `WMSLayer` object.

Examples

Find all layers that contain temperature data and return a `WMSLayer` array:

```
layers = wmsfind('temperature');
```

Find all layers that contain global temperature data and return a `WMSLayer` array:

```
layers = wmsfind('global*temperature');
```

Find all layers that contain an exact match for `'Rivers'` in the `LayerTitle` field and return a `WMSLayer` array:

```
layers = wmsfind('Major Rivers', 'MatchType', 'exact', ...
   'IgnoreCase', false, 'SearchFields', 'layertitle');
```

Find all layers that contain a partial match for `'elevation'` in the `LayerName` field and return a `WMSLayer` array:

```
layers = wmsfind('elevation', 'SearchField', 'layername');
```

Find all unique servers that contain `'BlueMarbleNG'` as a layer name:

```
layers = wmsfind('BlueMarbleNG', ...
   'SearchField', 'layername', 'MatchType', 'exact');
servers = layers.servers;
```

Find layers that contain elevation data for Colorado and return a `WMSLayer` array:

```
latlim = [35,43];
lonlim = [-111,-101];
layers = wmsfind('elevation', ...
   'Latlim', latlim, 'Lonlim', lonlim);
```

Find all layers that contain temperature data for a point in Perth, Australia, and return a `WMSLayer` array:

```
lat = -31.9452;
lon = 115.8323;
layers = wmsfind('temperature', 'Latlim', lat, 'Lonlim', lon);
```

Find all the layers provided by servers located at the Jet Propulsion Laboratory (JPL). Display to the command window each server URL, layer title, and layer name:

```
layers = wmsfind('jpl.nasa.gov', 'SearchField', 'serverurl');
layers.disp('Properties', {'serverURL', 'layerTitle','layerName'});
```

Find all unique URLs of government servers:

```
layers = wmsfind('*.gov*', 'SearchField', 'serverurl');
servers = layers.servers;
```

Perform multiple searches. Find all layers that contain temperature in the layer name or title fields:

```
temperature = wmsfind('temperature', ...
   'SearchField',{'layertitle', 'layername'});
```

Find sea surface temperature layers:

```
sst = temperature.refine('sea surface');
```

Find and display to the command window a list of global sea surface temperature layers:

```
global_sst = sst.refine('global')
```

Perform multiple listings and searches of the entire WMS database. Please note that finding all the layers from the WMS database may take several seconds to execute and require a substantial amount of memory.

```
layers = wmsfind('*');
```

Sort and display to the command window the unique layer titles in the WMS database:

```
layerTitles = sort(unique({layers.LayerTitle}))'
```

Refine `layers` to include only layers with global coverage:

```
global_layers = layers.refineLimits('Latlim', [-90 90], ...
   'Lonlim', [-180 180]);
```

Refine `global_layers` to contain only topography layers that have global extent:

```
topography = global_layers.refine('topography');
```

Refine `layers` to contain only layers that have the terms “oil” and “gas” in the `LayerTitle`:

```
oil_gas = layers.refine('oil*gas', 'SearchField', 'layertitle');
```

See Also

wmsinfo | WMSLayer on page 2-6 | wmsread | wmsupdate

wmsinfo

Purpose

Information about WMS server from capabilities document

Syntax

```
[capabilities, infoRequestURL] = wmsinfo(serverURL)
[capabilities, infoRequestURL] = wmsinfo(infoRequestURL)
[capabilities, infoRequestURL] = wmsinfo(..., Name,Value)
```

Description

`[capabilities, infoRequestURL] = wmsinfo(serverURL)` accesses the Internet to read a capabilities document from a Web Map Service (WMS) server. A capabilities document is an XML document that contains metadata describing the geographic content offered by the server. The `wmsinfo` function returns the contents of the capabilities document into `capabilities`, a `WMSCapabilities` object. The WMS server URL `serverURL` contains the protocol `'http://'` or `'https://'` and additional WMS or access keywords. You can insert the URL string `infoRequestURL`, composed of the `serverURL` with additional WMS parameters, into a browser or `urlread` to return the XML capabilities document. The `wmsinfo` function requires an Internet connection. Periodically, the WMS server is unavailable. Retrieving the map can take several minutes.

`[capabilities, infoRequestURL] = wmsinfo(infoRequestURL)` reads the capabilities document from a WMS `infoRequestURL` and returns the contents into `capabilities`.

`[capabilities, infoRequestURL] = wmsinfo(..., Name,Value)` specifies a parameter-value pair that modifies the request to the server.

Tips

- To specify a proxy server to connect to the Internet, select **File>Preferences>Web** and enter your proxy information. Use this feature if you have a firewall.
- `wmsinfo` communicates with the server using a `WebMapServer` handle object representing an implementation of a WMS specification. The handle object acts as a proxy to a WMS server and resides physically on the client side. The handle object accesses the server's capabilities document. The handle object supports multiple WMS versions and negotiates with the server to use the highest known version that the

server can support. The handle object automatically times-out after 60 seconds if a connection is not made to the server.

Input Arguments

serverURL

WMS server URL that contains the protocol `'http://'` or `'https://'` and additional WMS or access keywords.

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

You can abbreviate the parameter name, which is case-insensitive.

TimeoutInSeconds

Integer-valued, scalar double that indicates the number of seconds to elapse before a server times out. A value of 0 causes the time-out mechanism to be ignored.

Default: 60 seconds

Output Arguments

capabilities

`WMSCapabilities` object.

infoRequestURL

URL string composed of the `serverURL` with additional WMS parameters.

Examples

Use `wmsinfo` to read a capabilities document and display the abstract of the first layer.

```
% Read the capabilities document from the NASA Goddard
% Space Flight Center WMS server.
```

```
serverURL = 'http://svs.gsfc.nasa.gov/cgi-bin/wms?';
capabilities = wmsinfo(serverURL);

% Display the layer information in the command window.
capabilities.Layer
```

Sample output follows:

```
        Index: 304
     ServerTitle: 'NASA SVS Image Server'
       ServerURL: 'http://svs.gsfc.nasa.gov/cgi-bin/wms?'
      LayerTitle: '(4096x2048 Animation)'
       LayerName: '3348_27724'
          Latlim: [-90.0000 90.0000]
          Lonlim: [-180.0000 180.0000]
        Abstract: 'NASA's Aqua satellite was launched ...
CoordRefSysCodes: {'CRS:84'}
         Details: [1x1 struct]


% Refine the list to include only layers with the term
% "glacier retreat" in the LayerTitle.
glaciers = capabilities.Layer.refine('glacier retreat', ...
   'SearchFields', 'LayerTitle');

% Display the abstract of the first layer.
glaciers(1).Abstract
```

Sample output follows:

```
Since measurements of Jakobshavn Isbrae were
first taken....
```

See Also

WebMapServer | WMSCapabilities | wmsfind | WMSLayer | wmsread

Purpose

Web Map Service layer object

Description

A `WMSLayer` object describes a Web Map Service (WMS) layer or layers. Obtain a `WMSLayer` object by using `wmsfind` or `wmsinfo`. The function `wmsfind` returns a `WMSLayer` array. The function `wmsinfo` returns a `WMSCapabilities` object, which contains a `WMSLayer` array in its `Layer` property.

Construction

`layers = WMSLayer(param, val, ...)` constructs a `WMSLayer` object from the input parameter names and values. If a parameter name matches a property name of the `WMSLayer` class (`ServerTitle`, `ServerURL`, `LayerTitle`, `LayerName`, `Latlim`, `Lonlim`, `Abstract`, `CoordRefSysCodes`, or `Details`) then the values of the parameter are copied to the property. The size of the output `layers` is scalar unless all inputs are cell arrays, in which case, the size of `layers` matches the size of the cell arrays.

Properties

You can only set the `'Latlim'` and `'Lonlim'` properties, which have public set access.

ServerTitle

Descriptive information about the server

Data Type: string

Default: `''`

ServerURL

The URL of the server

Data Type: string

Default: `''`

LayerTitle

Descriptive information about the layer; clarifies the meaning of the raster values of the layer

Data Type: string

Default: ''

LayerName

The keyword the server uses to retrieve the layer

Data Type: string

Default: ''

Latlim

The southern and northern latitude limits of the layer in units of degrees and in the range [-90, 90].

Data Type: two-element vector

Default: []

Lonlim

The western and eastern longitude limits of the layer in units of degrees. The limits must be ascending and in the range [-180, 180] or [0 360].

Data Type: two-element vector

Default: []

Abstract

Information about the layer

Data Type: string

Default: ''

CoordRefSysCodes

String codes of available coordinate reference systems

Data Type: cell array

Default: {}

Details

Detailed information about the layer: MetadataURL, Attributes, Scale, Dimension, Style. See the `WMSLayer.Details` reference page for more information.

Data Type: structure

Methods

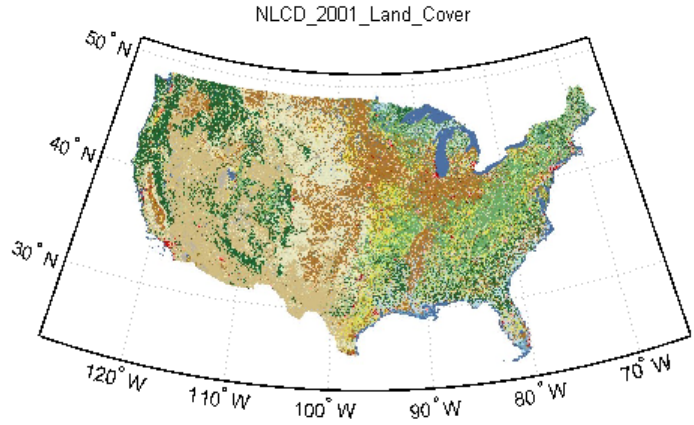
disp	Display properties
refine	Refine search
refineLimits	Refine search based on geographic limits
servers	Return URLs of unique servers
serverTitles	Return titles of unique servers

Examples

Construct a `WMSLayer` object from a WMS `GetMap` request URL:

```
serverURL = ['http://ims.cr.usgs.gov:80/wmsconnector/' ...
    'com.esri.wms.Esrimap/USGS_EDC_LandCover_NLCD2001?'];
requestURL = [serverURL 'SERVICE=WMS&FORMAT=image/jpeg&' ...
    'REQUEST=GetMap&' ...
    'STYLES=&SRS=EPSG:4326&VERSION=1.1.1&', ...
    'LAYERS=NLCD_2001_Land_Cover&', ...
    'WIDTH=1024&HEIGHT=470&' ...
    'BBOX=-128,23,-65,51&'];

% Construct the WMSLayer object by using the serverURL
% variable and the value of the WMS LAYERS parameter.
```

```
% Update the remaining information from the server.
layer = WMSLayer('ServerURL', serverURL, ...
    'LayerName', 'NLCD_2001_Land_Cover');
layer = wmsupdate(layer)

% Request the layer from the server using the WMS request
% parameters found in the requestURL string. Copy the WMS
% BBOX information to the latlim and lonlim parameters.
% Copy the WMS WIDTH and HEIGHT values to the ImageWidth and
% ImageHeight parameters.
lonlim = [-128, -65];
latlim = [23, 51];
[A, R] = wmsread(layer, 'Latlim', latlim, 'Lonlim', lonlim, ...
    'ImageHeight', 470 , 'ImageWidth', 1024);

% Display the rendered image.
figure
usamap(A, R)
geoshow(A, R)
title(layer.LayerTitle, 'Interpreter', 'none')

% The image can also be retrieved using the requestURL.
[A, R] = wmsread(requestURL);
```



Courtesy U.S. Geological Survey

See Also

`WebMapServer` | `WMSCapabilities` | `wmsfind` | `wmsinfo` | `WMSMapRequest` | `wmsread` | `wmsupdate`

WMSLayer.disp

Purpose

Display properties

Syntax

```
layers.disp(..., Name,Value, ...)
```

Description

`layers.disp(..., Name,Value, ...)` displays the index number followed by the property names and property values of the layer. Additional options are specified by one or more `Name,Value` pair arguments.

Input Arguments

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

You can abbreviate parameter names, and case does not matter.

Properties

String or cell array of strings that determines which properties appear as output and the order in which they appear. Permissible values are: `'servertitle'`, `'servername'`, `'layertitle'`, `'layername'`, `'latlim'`, `'lonlim'`, `'abstract'`, `'coordrefsyscodes'`, `'details'`, or `'all'`. To list all the properties, set `'Properties'` to `'all'`.

Default: `'all'`

Label

A case-insensitive string with permissible values of `'on'` or `'off'`. If you set `'Label'` to `'on'`, then the property name appears followed by its value. If you set `'Label'` to `'off'`, then only the property value appears in the output.

Default: `'on'`

Index

A case-insensitive string with permissible values of `'on'` or `'off'`. If you set `'Index'` to `'on'`, then `WMSLayer.disp` lists the element's index in the output. If you set `'Index'` to `'off'`, then `WMSLayer.disp` does not list the index value in the output.

Default: `'on'`

Examples

Display `LayerTitle` and `LayerName` properties to the command window:

```
layers = wmsfind('srtm30plus');
layers(1:5).disp( 'Index', 'off', ...
      'Properties',{'layertitle','layername'});
```

Sample output follows:

```
LayerTitle: 'SRTM30Plus World with Backdrop'
 LayerName: '10:4'
```

Sort and display the `LayerName` property and index:

```
layers = wmsfind('elevation');
[layerNames, index] = sort({layers.LayerName});
layers = layers(index);
layers.disp('Label','off', 'Properties', 'layername');
```

Sample output follows:

```
           Index: 1418
'topp:elevation_earth_300sec'

           Index: 1419
'topp:elevation_europe_150sec'
```

```
                Index: 1420
'topp:elevation_europe_150sec'
```

See Also

wmsfind

Purpose

Refine search

Syntax

```
layers.refine(querystr, Name,Value, ...)
```

Description

`layers.refine(querystr, Name,Value, ...)` searches for elements of `layers` in which values of the `Layer` or `LayerName` properties match the string *`querystr`*. Use the `'MatchType'` property to control whether the method uses partial or exact matching. The default is partial matching.

Input Arguments

querystr

Specifies the search string.

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

You can abbreviate parameter names and case does not matter.

SearchFields

Case-insensitive string or cell array of strings. Valid strings are `'abstract'`, `'layer'`, `'layertitle'`, `'layername'`, `'server'`, `'serverurl'`, `'servertitle'`, or `'any'`.

Default: `{'layer'}`

MatchType

Case-insensitive string with value `'partial'` or `'exact'`. If you specify `'MatchType'` as `'partial'`, then a match is determined if the query string is found in the property value. If you specify `'MatchType'` as `'exact'`, then a match is determined only if the query string exactly matches the property value. If you specify

'MatchType' as 'exact' and querystr as '*', a match is found if the property value matches the character '*'.

Default: 'partial'

IgnoreCase

Logical. If you set 'IgnoreCase' to true, then WMSLayer.refine ignores case when performing string comparisons.

Default: true

Tips

- The WMSLayer.refine method searches the entries in the 'SearchFields' properties of layers for a partial match of the entry with querystr. The WMSLayer.refine method returns layer information if any supplied 'SearchFields' match. If you specify 'layer', then the method searches both the 'LayerTitle' and 'LayerName' properties. If you specify 'server', then the method searches both the 'ServerURL' and 'ServerTitle' fields. If you specify 'any', then the method searches the properties 'Abstract', 'LayerTitle', 'LayerName', 'ServerURL', and 'ServerTitle'.

Examples

Refine a search of temperature layers to find two different sets of layers: (1) layers containing only annual sea surface temperatures, and (2) layers containing annual temperatures or sea surface temperatures.

```
temperature = wmsfind('temperature');
annual = temperature.refine('annual');
sst = temperature.refine('sea surface');
annual_and_sst = sst.refine('annual');
annual_or_sst = [sst;annual];
```

See Also

wmsfind | WMSLayer.refineLimits

Purpose

Refine search based on geographic limits

Syntax

```
layers.refineLimits(Name,Value, ...)
```

Description

`layers.refineLimits(Name,Value, ...)` searches for elements of `layers` that match specific latitude or longitude limits. The results include a given layer only if the quadrangle specified by the optional `'Latlim'` and `'Lonlim'` parameters fully contains the boundary quadrangle, as defined by the `Latlim` and `Lonlim` properties. Partial overlap does not result in a match.

Tips

- The default value of `[]` for either `'Latlim'` or `'Lonlim'` implies that all layers match the criteria. For example, if you specify the following, then the results include all the layers that cover the northern hemisphere.

  ```
  layer.refineLimits('Latlim', [0 90], 'Lonlim', [])
  ```

Input Arguments

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

You can abbreviate `'Latlim'` and `'Lonlim'`. Case does not matter. All angles are in units of degrees.

Latlim

A two-element vector of latitude specifying the latitudinal limits of the search in the form [`southern_limit northern_limit`] or a scalar value representing the latitude of a single point.

Lonlim

A two-element vector of longitude specifying the longitudinal limits of the search in the form [western_limit eastern_limit] or a scalar value representing the longitude of a single point.

Examples

Find layers containing global elevation data:

```
elevation = wmsfind('elevation');
latlim = [-90, 90];
lonlim = [-180, 180];
globalElevation = ...
   elevation.refineLimits('Latlim', latlim, 'Lonlim', lonlim);

 % Print out the server titles from the unique servers.
globalElevation.serverTitles'
```

Sample output follows:

```
ans =

    'Global'
    'NRL GIDB Portal: Missouri CARES Maps'
    'NRL GIDB Portal: NOAA NGDC Maps'
```

See Also

wmsfind

Purpose

Return URLs of unique servers

Syntax

```
servers = layers.servers()
```

Description

`servers = layers.servers()` returns a cell array of URLs of unique servers.

Examples

Find all unique URLs of government servers:

```
layers = wmsfind('*.gov*','SearchField', 'serverurl');
servers = layers.servers;
sprintf('%s\n', servers{:})
```

Sample output follows:

```
http://www.ga.gov.au/bin/getmap.pl?dataset=national
http://www.geoportaligm.gov.ec/nacional/wms?
http://www.geoportaligm.gov.ec/regional/wms?
```

For each server that contains a temperature layer, list the server URL and the number of temperature layers:

```
temperature = wmsfind('temperature');
servers = temperature.servers;
for k=1:numel(servers)
   querystr = servers{k};
   layers = temperature.refine(querystr, ...
      'SearchFields', 'serverurl');
   fprintf('Server URL\n%s\n', layers(1).ServerURL);
   fprintf('Number of layers: %d\n\n', numel(layers));
end
```

Sample output follows:

```
Server URL
http://svs.gsfc.nasa.gov/cgi-bin/wms?
```

```
Number of layers: 36
```

See Also

wmsfind | WMSLayer.refine | WMSLayer.serverTitles

Purpose

Return titles of unique servers

Syntax

```
serverTitles = layers.serverTitles()
```

Description

`serverTitles = layers.serverTitles()` returns a cell array of titles of unique servers.

Examples

List titles of unique government servers:

```
layers = wmsfind('*.gov*', 'SearchField', 'serverurl');
titles = layers.serverTitles
sprintf('%s\n', titles{:})
```

Sample output follows:

```
High Resolution Nighttime Imagery (Las Vegas)
```

See Also

`wmsfind` | `WMSLayer.servers`

WMSLayer.Details property

Description

A structure containing detailed information about a layer

Details Structure

Field Name	Data Type	Field Content
`MetadataURL`	String	URL containing metadata information about layer.
`Attributes`	Structure	Attributes of layer.
`BoundingBox`	Structure array	Bounding box of layer.
`Dimension`	Structure array	Dimensional parameters of layer, such as time or elevation.
`ImageFormats`	Cell array	Image formats supported by server.
`ScaleLimits`	Structure	Scale limits of layer.
`Style`	Structure array	Style parameters that determine layer rendering.
`Version`	String	WMS version specification.

Attributes Structure

Field Name	Data Type	Field Content
`Queryable`	Logical	`True` if you can query the layer for feature information.
`Cascaded`	`Double`	Number of times a Cascading Map server has retransmitted the layer.
`Opaque`	Logical	`True` if the map data are mostly or completely opaque.

Attributes Structure (Continued)

Field Name	Data Type	Field Content
`NoSubsets`	Logical	`True` if the map must contain the full bounding box. `false` if the map can be a subset of the full bounding box.
`FixedWidth`	Logical	`True` if the map has a fixed width that the server cannot change. `false` if the server can resize the map to an arbitrary width.
`FixedHeight`	Logical	`True` if the map has a fixed height that the server cannot change. `false` if the server can resize the map to an arbitrary height.

BoundingBox Structure

Field Name	Data Type	Field Content
`CoordRefSysCode`	String	Code number for coordinate reference system.
`XLim`	Double array	X limit of layer in units of coordinate reference system.
`YLim`	Double array	Y limit of layer in units of coordinate reference system.

Dimension Structure

Field Name	Data Type	Field Content
`Name`	String	Name of the dimension; such as time, elevation, or temperature.
`Units`	String	Measurement unit.
`UnitSymbol`	String	Symbol for unit.
`Default`	String	Default dimension setting. For example, if `default` is `'time'` and dimension is not specified, server returns time holding.
`MultipleValues`	Logical	`True` if multiple values of the dimension may be requested. `false` if only single values may be requested.
`NearestValue`	Logical	`True` if nearest value of dimension is returned in response to request for nearby value. `false` if request value must correspond exactly to declared extent values.
`Current`	Logical	`True` if temporal data are kept current (valid only for temporal extents).
`Extent`	String	Values for dimension. Expressed in any of the following ways: • Single value (`value`) • List of values (`value1, value2, ...`) • Interval defined by bounds and resolution (`min1/max1/res1`)

Dimension Structure (Continued)

Field Name	Data Type	Field Content
		• List of intervals (`min1/max1/res1, min2/max2/res2, ...`)

ScaleLimits Structure

Field Name	Data Type	Field Content
`ScaleHint`	Double array	Minimum and maximum scales for which it is appropriate to display layer. Expressed as scale of ground distance in meters represented by diagonal of central pixel in image.
`MinScaleDenominator`	Double	Minimum scale denominator of maps for which a layer is appropriate.
`MaxScaleDenominator`	Double	Maximum scale denominator of maps for which a layer is appropriate.

Style Structure Array

Field Name	Data Type	Field Content
`Title`	String	Descriptive title of style.
`Name`	String	Name of style.

Style Structure Array (Continued)

Field Name	Data Type	Field Content
`Abstract`	String	Information about style.
`LegendURL`	Structure	Information about legend graphics.

LegendURL Structure

Field Name	Data Type	Field Content
`OnlineResource`	String	URL of legend graphics.
`Format`	String	Format of legend graphics.
`Height`	Double	Height of legend graphics.
`Width`	Double	Width of legend graphics.

Purpose

Web Map Service map request object

Description

A `WMSMapRequest` object contains a request to a WMS server to obtain a map, which represents geographic information. The WMS server renders the map as a color or grayscale image. The object contains properties that you can set to control the geographic extent, rendering, or size of the requested map.

Construction

`mapRequest = WMSMapRequest(layer)` constructs a `WMSMapRequest` object. The `WMSLayer` array `layer` contains only one unique `ServerURL`. The `WMSMapRequest` class updates the properties of `layer`, if necessary.

`mapRequest = WMSMapRequest(layer, server)` constructs a `WMSMapRequest` object. `layer` is a `WMSLayer` object, and `server` is a scalar `WebMapServer` object. The `ServerURL` property of `layer` must match the `ServerURL` property of `server`. The `server` object updates `layer` properties.

Properties

Server

Initialized to the `Server` input, if supplied to the constructor; otherwise constructed using the `ServerURL` of `Layer`.

Data Type: scalar `WebMapServer` object

Layer

Initialized to the `layer` input supplied to the constructor. The `Layer` property contains one unique `ServerURL`. The `Server` property updates the properties of `Layer` when the property is set. The `ServerURL` property of `Layer` must match the `ServerURL` property of `Server`.

Data Type: `WMSLayer` array

CoordRefSysCode

Specifies the coordinate reference system code. Its default value is `'EPSG:4326'`. If `'EPSG:4326'` is not found in `Layer.CoordRefSysCodes`, then the `CoordRefSysCode`

value is set from the first `CoordRefSysCode` found in the `Layer.Details.BoundingBox` structure array. When `CoordRefSysCode` is set to `'EPSG:4326'` or `'CRS:84'`, the `XLim` and `YLim` properties are set to `[]` and the `Latlim` and `Lonlim` properties are set to the geographic extent defined by the `Layer` array. When `CoordRefSysCode` is set to a value other than `'EPSG:4326'` or `'CRS:84'`, then the `XLim` and `YLim` properties are set from the values found in the `Layer.Details.BoundingBox` structure and the `Latlim` and `Lonlim` properties are set to `[]`. Automatic projections are not supported. (Automatic projections begin with the string `'AUTO'`.)

Data Type: string

Default: `'EPSG:4326'`

RasterRef

References the raster map to an intrinsic coordinate system.

Data Type: 3-by-2 matrix

Latlim

Contains the southern and northern latitudinal limits of the request in units of degrees. The limits must be ascending.

Data Type: two-element vector

Default: Limits that span all latitudinal limits found in the `Layer.Latlim` property

Lonlim

Contains the western and eastern longitudinal limits of the request in units of degrees. The limits must be ascending and in the range [-180, 180] or [0 360].

Data Type: two-element vector

Default: Limits that span all longitudinal limits in the `Layer.Lonlim` property

XLim

Contains the western and eastern limits of the request in units specified by the coordinate reference system. The limits must be ascending. You can set `XLim` only if you set `CoordRefSysCode` to a value other than `EPSG:4326`.

Data Type: two-element vector

Default: `[]`

YLim

Contains the southern and northern limits of the request in units specified by the coordinate reference system. The limits must be ascending. You can set `YLim` only if you set `CoordRefSysCode` to a value other than `EPSG:4326`.

Data Type: two-element vector

Default: `[]`

ImageHeight

Specifies the height in pixels for the requested raster map. The property `MaximumHeight` defines the maximum value for `ImageHeight`. The `WMSMapRequest` class initializes the `ImageHeight` property to either 512 or to an integer value that best preserves the aspect ratio of the coordinate limits, without changing the coordinate limits.

Data Type: scalar, positive integer

ImageWidth

Specifies the width in pixels for the requested raster map. The property `MaximumWidth` defines the maximum value for `ImageWidth`. The `WMSMapRequest` class initializes the `ImageWidth`

property to either 512 or to an integer value that best preserves the aspect ratio of the coordinate limits, without changing the coordinate limits.

Data Type: scalar, positive integer

Maximum Height

Contains the maximum height in pixels for the requested map. Cannot be set. The value of `MaximumHeight` is 8192.

Data Type: `double`

Maximum Width

Contains the maximum width in pixels for the requested map. Cannot be set. The value of `MaximumWidth` is 8192.

Data Type: `double`

Elevation

Gives the elevation extent of the requested map. When you set the property, `'elevation'` must be the value of the `Layer.Details.Dimension.Name` field.

Data Type: string

Default: `''`

Time

Specifies the time extent of the requested map. See the `WMSMapRequest.Time` reference page for more information.

Data Type: string or double

Default: `''`

SampleDimension

Contains the name of a sample dimension (other than `'time'` or `'elevation'`) and its value. `SampleDimension{1}` must be the value of the `Layer.Details.Dimension.Name` field.

Data Type: two-element cell array of strings

Transparent

Specifies whether the map background is transparent. When you set `Transparent` to `true`, the server sets all pixels not representing features or data values in that layer to a transparent value, producing a composite map. When you set `Transparent` to `false`, the server sets all non-data pixels to the value of the background color.

Data Type: logical scalar

Default: `false`

BackgroundColor

Specifies the color of the background (non-data) pixels of the map. The values range from 0 to 255. The default value, `[255,255,255]`, specifies the background color as white. You can set `BackgroundColor` using `non-uint8` numeric values, but they are cast and stored as `uint8`.

Data Type: three-element vector of `uint8` values

StyleName

Specifies the style to use when rendering the image. The `StyleName` must be a valid entry in the `Layer.Details.Style.Name` field. (The cell array of strings contains the same number of elements as does `Layer`.)

Data Type: string or cell array of strings

Default: `{}`

ImageFormat

Specifies the desired image format used to render the map as an image. If set, the format must match an entry in the `Layer.Details.ImageFormats` cell array and an entry in the `ImageRenderFormats` property. If not set, the format defaults to a value in the `ImageRenderFormats` property.

Data Type: string

ImageRenderFormats

Contains the preferred image rendering formats when `Transparent` is set to `false`. The first entry is the most preferred image format. If the preferred format is not stored in the `Layer` property, then the next format from the list is selected, until a format is found. The `ImageRenderFormats` array is not used if the `ImageFormat` property is set. The `ImageRenderFormats` property cannot be set.

Data Type: cell array

ImageTransparentFormats

Contains the preferred image rendering formats when `Transparent` is set to `true`. When `Transparent` is set to `true`, the `ImageFormat` property is set to the first entry in the `ImageTransparentFormats` list, if it is stored in the `Layer` property. Otherwise, the list is searched for the next element, until a match is found. If a transparent image format is not found in the list, or if the `ImageFormat` property is set to a non-default value, then `ImageFormat` is unchanged. The `ImageTransparentFormats` property cannot be set.

Data Type: cell array

ServerURL

Contains the server URL for the WMS `GetMap` request. In general, `ServerURL` matches the `ServerURL` of the `Layer`. However, some WMS servers, such as the Microsoft TerraServer, require a different URL for `GetMap` requests than for WMS `GetCapabilities` requests.

Data Type: string

Default: `Layer(1).ServerURL`

RequestURL

Contains the URL for the WMS `GetMap` request. It is composed of the `ServerURL` with additional WMS parameter/value pairs. This property cannot be set.

Data Type: string

Methods

boundImageSize	Bound size of raster map

Examples

Read a global, half-degree resolution sea surface temperature map for the month of November 2009. The map, from the AMSR-E sensor on NASA's Aqua satellite, uses data provided by NASA's Earth Observations (NEO) WMS server.

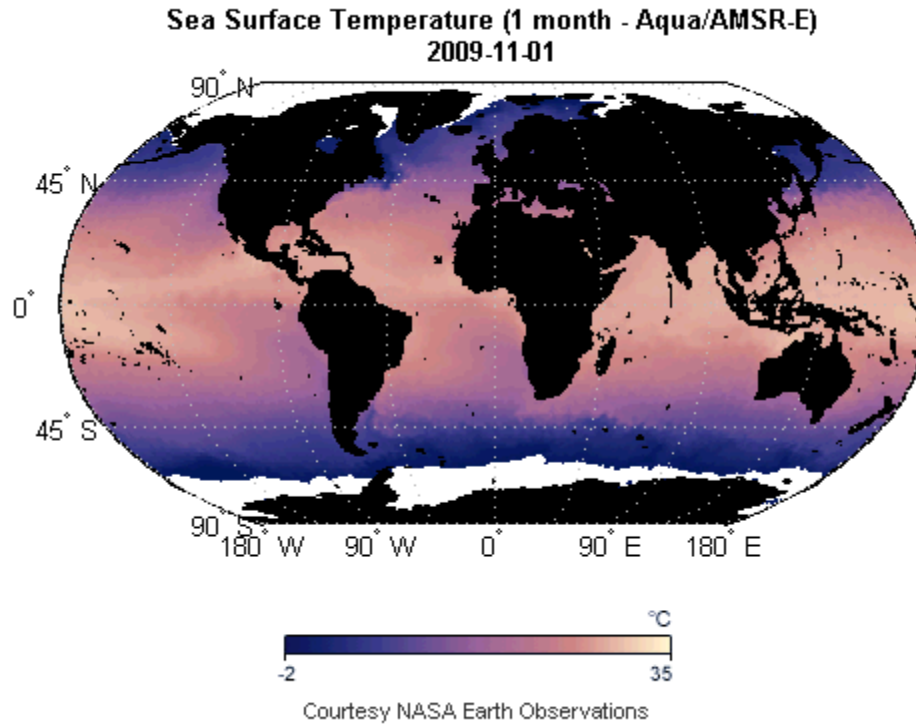
```
sst =  wmsfind('AMSRE_SST_M');
server = WebMapServer(sst.ServerURL);
mapRequest = WMSMapRequest(sst, server);
timeRequest = '2009-11-01';
mapRequest.Time = timeRequest;
samplesPerInterval = .5;
mapRequest.ImageHeight = ...
   round(abs(diff(sst.Latlim))/samplesPerInterval);
mapRequest.ImageWidth = ...
   round(abs(diff(sst.Lonlim))/samplesPerInterval);
mapRequest.ImageFormat = 'image/png';
sstImage = server.getMap(mapRequest.RequestURL);
```

The legend for the layer can be obtained via the `OnlineResource` URL field in the `LegendURL` structure. The legend shows that the temperature ranges from -2 to 35 degrees Celsius. The `WMSMapRequest` object updates the layer information from the server.

```
[legend, cmap] = imread...
    (mapRequest.Layer.Details.Style(1).LegendURL.OnlineResource);
if isempty(cmap)
   legendImg = legend;
else
   legendImg = ind2rgb(legend, cmap);
end
```

Display the temperature map and legend.

```
figure('Color','white')
worldmap world
setm(gca, 'MlabelParallel', -90, 'MlabelLocation', 90)
geoshow(sstImage, mapRequest.RasterRef);
title({mapRequest.Layer.LayerTitle, timeRequest}, ...
   'Interpreter', 'none', 'FontWeight', 'bold')

figurePosition = get(gcf, 'position');
centerWidth = figurePosition(3)/2;
left = centerWidth - size(legendImg,2)/2;
bottom = 30;
width  = size(legendImg,2);
height = size(legendImg,1);
axes('Units', 'pixels', 'Position', [left bottom width height])
image(legendImg)
axis off
```



Additional abstract information for this layer can be obtained from the `MetadataURL` field.

```
filename = [tempname '.xml'];
urlwrite(mapRequest.Layer.Details.MetadataURL, filename);
xml = xmlread(filename);
delete(filename);
xml.getElementsByTagName('abstract').item(0).getTextContent
```

The output appears as shown.

```
ans =
```

```
<p>Sea surface temperature is the temperature of the top
millimeter of the ocean's surface. Sea surface temperatures
influence weather, including hurricanes, as well as plant
and animal life in the ocean. Like Earth's land surface,
sea surface temperatures are warmer near the equator and
colder near the poles. Currents like giant rivers move
warm and cold water around the world's oceans. Some of
these currents flow on the surface, and they are obvious
in sea surface temperature images. Special microwave
technology allows the AMSR-E sensor on NASA's Aqua satellite
to measure sea surface temperatures through clouds, something
no satellite sensor before it was able to do across the
whole globe.</p>
```

See Also

WebMapServer | wmsfind | wmsinfo | WMSLayer | wmsread

Purpose

Bound size of raster map

Syntax

```
mapRequest = boundImageSize(mapRequest, imageLength)
```

Description

`mapRequest = boundImageSize(mapRequest, imageLength)` bounds the size of the raster map based on the scalar `imageLength`. The scalar `mapRequest` is a `WMSMapRequest` object. The double `imageLength` indicates the length in pixels for the row (`ImageHeight`) or column (`ImageWidth`) dimension. The `boundImageSize` method calculates the row or column dimension length by using the aspect ratio of the `Latlim` and `Lonlim` properties or the aspect ratio of the `XLim` and `YLim` properties, if they are set.

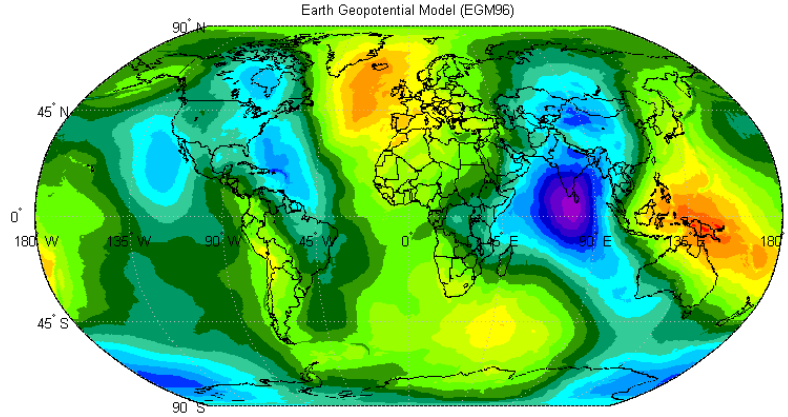
The `boundImageSize` method measures image dimensions in geographic or map coordinates. The method sets the longest image dimension to `imageLength`, and the shortest to the nearest integer value that preserves the aspect ratio, without changing the coordinate limits. The maximum value of the `MaximumHeight` and `MaximumWidth` properties becomes the maximum value of `imageLength`.

Examples

Read and display a composite of multiple layers representing the EGM96 geopotential model of the Earth, coastlines, and national boundaries from the NASA Globe Visualization server. The rendered map has a spatial resolution of 0.5 degree.

```
vizglobe = wmsfind('viz.globe', 'SearchField', 'serverurl');
coastlines = vizglobe.refine('coastline');
national_boundaries = vizglobe.refine('national*bound');
base_layer = vizglobe.refine('egm96');
layers = [base_layer;coastlines;national_boundaries];
request = WMSMapRequest(layers);
request.Transparent = true;
request = request.boundImageSize(720);
overlayImage = request.Server.getMap(request.RequestURL);

figure
worldmap('world')
```

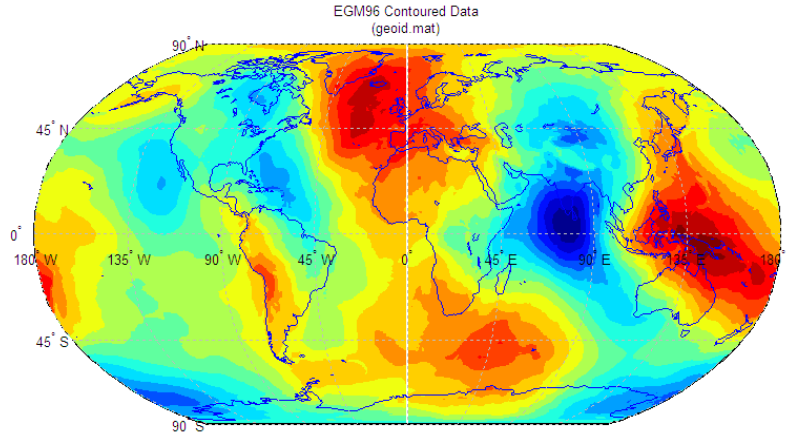
```
geoshow(overlayImage, request.RasterRef);
title(base_layer.LayerTitle)
```



Courtesy NASA/Goddard Space Flight Center Scientific Visualization Studio

Compare the map with the contoured data from `'geoid.mat'`.

```
geoid = load('geoid');
coast = load('coast');
figure
worldmap('world')
contourfm(geoid.geoid, geoid.geoidrefvec, 15)
geoshow(coast.lat, coast.long)
title({'EGM96 Contoured Data', '(geoid.mat)'})
```



Downsampled from the EGM96 grid developed by NASA Goddard and the National Geospatial-Intelligence Agency (NGA)

WMSMapRequest.Time property

Purpose

Requested time extent

Description

The `WMSMapRequest.Time` property stores time as a string or a double indicating the desired time extent of the requested map. When you set the property, `'time'` must be the value of the `Layer.Details.Dimension.Name` field. The default value is `''`.

Time is stored in the ISO® 8601:1988(E) extended format. In general, the `Time` property is stored in a `yyyy-mm-dd` format or a `yyyy-mm-ddThh:mm:ssZ` format, if the precision requires hours, minutes, or seconds. You can use several different string and numeric formats to set the `Time` property, according to the following table (where dateform number is the number used by the Standard MATLAB Date Format Definitions). Express all hours, minutes, and seconds in Coordinated Universal Time (UTC).

Dateform (number)	Input (string)	Stored format
0	`dd-mm-yyyy HH:MM:SS`	yyyy-mm-ddTHH:MM:SSZ
1	`dd-mm-yyyy`	yyyy-mm-dd
2	`mm/dd/yy`	yyyy-mm-dd
6	`mm/dd`	yyyy-mm-dd (current year)
10	`yyyy`	yyyy
13	`HH:MM:SS`	yyyy-mm-ddTHH:MM:SSZ
14	`HH:MM:SS PM`	yyyy-mm-ddTHH:MM:SSZ
15	`HH:MM`	yyyy-mm-ddTHH:MM:00Z
16	`HH:MM PM`	yyyy-mm-ddTHH:MM:00Z
21	`mmm.dd,yyyy HH:MM:SS`	yyyy-mm-ddTHH:MM:SSZ
22	`mmm.dd,yyyy`	yyyy-mm-dd
23	`mm/dd/yyyy`	yyyy-mm-dd

Dateform (number)	Input (string)	Stored format
26	`yyyy/mm/dd`	yyyy-mm-dd
29	`yyyy-mm-dd`	yyyy-mm-dd
30	`yyyymmddTHHMMSS`	yyyy-mm-ddTHH:MM:SSZ
31	`yyyy-mm-dd HH:MM:SS`	yyyy-mm-ddTHH:MM:SSZ

Inputs using the dateform numbers 13–16 return the date set to the current year, month, and day. Use of other dateform formats, especially 19, 20, 24, and 25, results in erroneous output.

In addition to these standard MATLAB dateform formats, the `WMSMapRequest.Time` property also accepts the following inputs.

Input (string)	Description
`'current'`	The current time holdings of the server
`numeric datenum`	Numeric date value converted to yyyy-mm-dd string (dateform 29 format)
`Byyyy`	B.C.E. year

Use the prefixes K, M, and G, followed by a string number (thousand, million, and billion years, respectively), for geologic data sets that refer to the distant past.

wmsread

Purpose

Retrieve WMS map from server

Syntax

```
[A, R] = wmsread(layer)
[A, R] = wmsread(mapRequestURL)
[A, R] = wmsread(layer, Name,Value, ...)
[A, R, mapRequestURL] = wmsread(...)
```

Description

`[A, R] = wmsread(layer)` accesses the Internet to render and retrieve a raster map from a Web Map Service (WMS) server. The `ServerURL` property of the `WMSLayer` object, `layer`, specifies the server. If `layer` has more than one element, then the server overlays each subsequent layer on top of the base (first) layer, forming a single image. The server renders multiple layers only if all layers share the same `ServerURL` value.

The WMS server returns a raster map, either a color or grayscale image, in the output `A`. The second output, a referencing matrix `R`, ties `A` to the EPSG:4326 geographic coordinate system. The rows of `A` are aligned with parallels, with even sampling in longitude. Likewise, the columns of `A` are aligned with meridians, with even sampling in latitude.

The geographic limits of `A` span the full latitude and longitude extent of `layer`. The `wmsread` function chooses the larger spatial size of `A` to match its larger geographic dimension. The larger spatial size is fixed at the value 512. In other words, assuming RGB output, `A` is `512-by-N-by-3` if the latitude extent exceeds longitude extent and `N-by-512-by-3` otherwise. In both cases `N` <= 512. The `wmsread` function sets `N` to the integer value that provides the closest possible approximation to equal cell sizes in latitude and longitude. The map spans the full extent supported for the `layer`.

`[A, R] = wmsread(mapRequestURL)` uses the input argument `mapRequestURL` to define the request to the server. The `mapRequestURL` string contains a WMS `serverURL` with additional WMS parameters. The URL string includes the WMS parameters `BBOX` and `GetMap` and the `EPSG:4326` or `CRS:84` keyword. Obtain a `mapRequestURL` from the output of `wmsread`, the `RequestURL` property of a `WMSMapRequest` object, or an Internet search.

`[A, R] = wmsread(layer, Name,Value, ...)` specifies parameter-value pairs that modify the request to the server. You can abbreviate parameter names, which are case-insensitive.

`[A, R, mapRequestURL] = wmsread(...)` returns a WMS `GetMap` request URL in the string `mapRequestURL`. You can insert the `mapRequestURL` into a browser to make a request to a server, which then returns the raster map. The browser opens the returned map if its mime type is understood, or saves the raster map to disk.

Tips

- Establish an Internet connection to use `wmsread`. Periodically, the WMS server is unavailable. Retrieving the map can take several minutes. `wmsread` communicates with the server using a `WebMapServer` handle object representing a WMS server. The handle object acts as a proxy to a WMS server and resides physically on the client side. The handle object retrieves the map from the server. The handle object automatically times-out after 60 seconds if a connection is not made to the server.
- To specify a proxy server to connect to the Internet, select **File > Preferences > Web** and enter your proxy information. Use this feature if you have a firewall.
- `wmsread` supports reading data in WMS versions 1.0.0, 1.1.1, and 1.3.0. For version 1.3.0 only, the WMS specification states, "EPSG:4326 refers to WGS 84 geographic latitude, then longitude. That is, in this CRS the *x*-axis corresponds to latitude, and the *y*-axis to longitude." Most servers provide data in this manner; however, some servers conform to version 1.1.1, where the *x*-axis corresponds to longitude and the *y*-axis to latitude.

  `wmsread` attempts to validate whether a server is confirming to the specification. It checks the EPSG:4326 bounding box, and if the `XLim` values exceeds the range of latitude, then the axes are swapped to conform to version 1.1.1 rather than 1.3.0. If `wmsread` does not detect that the `XLim` values exceed the range of latitude and you notice that the latitude and longitude limits are reversed, then you need to swap them. You can either modify the `bbox` parameters in the

mapRequestURL or modify the Latlim and Lonlim parameter values, if permissible.

Input Arguments

layer

WMSLayer object that contains information about the layer you are retrieving, such as the server URL. layer must contain either the string 'EPSG:4326' or 'CRS:84' in the CoordRefSysCodes property.

mapRequestURL

String that defines the request to the server.

Name-Value Pair Arguments

Specify optional comma-separated pairs of Name,Value arguments, where Name is the argument name and Value is the corresponding value. Name must appear inside single quotes (' '). You can specify several name and value pair arguments in any order as Name1,Value1,...,NameN,ValueN.

Latlim

Two-element vector that specifies the latitude limits of the output image in the form [southern_limit northern_limit]. The limits are in degrees and must be ascending. By default, 'Latlim' is empty, and the full extent in latitude of layer is used. If Layer.Details.Attributes.NoSubsets is true, then 'Latlim' may not be modified.

Lonlim

Two-element vector that specifies the longitude limits of the output image in the form [western_limit eastern_limit]. The limits are in degrees and must be ascending. By default, 'Lonlim' is empty and the full extent in longitude of layer is used. If Layer.Details.Attributes.NoSubsets is true, then 'Lonlim' may not be modified.

ImageHeight

Scalar, positive, integer-valued number that specifies the desired height of the raster map in pixels. `ImageHeight` cannot exceed 8192. If `layer.Details.Attributes.FixedHeight` contains a positive number, then you cannot modify `'ImageHeight'`.

ImageWidth

Scalar, positive, integer-valued number that specifies the desired width of the raster map in pixels. `ImageWidth` cannot exceed 8192. If `Layer.Details.Attributes.FixedWidth` contains a positive number, then you cannot modify `'ImageWidth'`.

CellSize

Scalar or two-element vector that specifies the target size of the output pixels (raster cells) in units of degrees. If you specify a scalar, the value applies to both height and width dimensions. If you specify a vector, use the form `[height width]`. The `wmsread` function issues an error if you specify both `CellSize` and `ImageHeight` or `ImageWidth`. The output raster map must not exceed a size of `[8192,8192]`.

RelTolCellSize

Scalar or two-element vector that specifies the relative tolerance for `'CellSize'`. If you specify a scalar, the value applies to both height and width dimensions. If you specify a vector, the tolerance appears in the order `[height width]`.

Default: `.001`

ImageFormat

String that specifies the desired image format for use in rendering the map as an image. If specified, the format must match an entry in the `Layer.Details.ImageFormats` cell array and must match one of the following supported formats: `'image/jpeg'`, `'image/gif'`, `'image/png'`, `'image/tiff'`, `'image/geotiff'`, `'image/geotiff8'`, `'image/tiff8'`, `'image/png8'`, `'image/bil'`. If not specified, the

format defaults to the first available format in the supported format list. When the `'image/bil'` format is specified, `A` is returned as a two-dimensional array with a class type of `int16` or `int32`.

StyleName

String or cell array of strings that specifies the style to use when rendering the image. By default, the style is set to the empty string. The `StyleName` must be a valid entry in the `Layer.Details.Style.Name` field. If you request multiple layers, each with a different style, then `StyleName` must be a cell array of strings.

Transparent

Logical that specifies if transparency is enabled. When you set `Transparent` to `true`, all pixels not representing features or data values are set to a transparent value. When you set `Transparent` to `false`, non-data pixels are set to the value of the background color.

Default: `false`

BackgroundColor

Three-element vector that specifies the color of the background (nondata) pixels of the map.

Default: `[255,255,255]`

Elevation

String that indicates the desired elevation extent of the requested map. The layer must contain elevation data, which is indicated by the `'Name'` field of the `Layer.Details.Dimension` structure. The `'Name'` field must contain the value `'elevation'`. The `'Extent'` field of the `Layer.Details.Dimension` structure determines the permissible range of values for the parameter.

Time

String or numeric date number that indicates the desired time extent of the requested map. The layer must contain data with a time extent, which is indicated by the `'Name'` field of the `Layer.Details.Dimension` structure. The `'Name'` field must contain the value `'time'`. The `'Extent'` field of the `Layer.Details.Dimension` structure determines the permissible range of values for the parameter. For more information about setting this parameter, see the `WMSMapRequest.Time` property reference page.

SampleDimension

Two-element cell array of strings that indicates the name of a sample dimension (other than `'time'` or `'elevation'`) and its string value. The layer must contain data with a sample dimension extent, which is indicated by the `'Name'` field of the `Layer.Details.Dimension` structure. The `'Name'` field must contain the value of the first element of `'SampleDimension'`. The `'Extent'` field of the `Layer.Details.Dimension` structure determines the permissible range of values for the second element of `'SampleDimension'`.

TimeoutInSeconds

Integer-valued, scalar double that indicates the number of seconds to elapse before a server time-out is issued. A value of 0 causes the time-out mechanism to be ignored.

Default: 60 seconds

Output Arguments

A

Color or grayscale image.

R

Referencing matrix that ties `A` to the EPSG:4326 geographic coordinate system.

mapRequestURL

String that lists a WMS `GetMap` request URL.

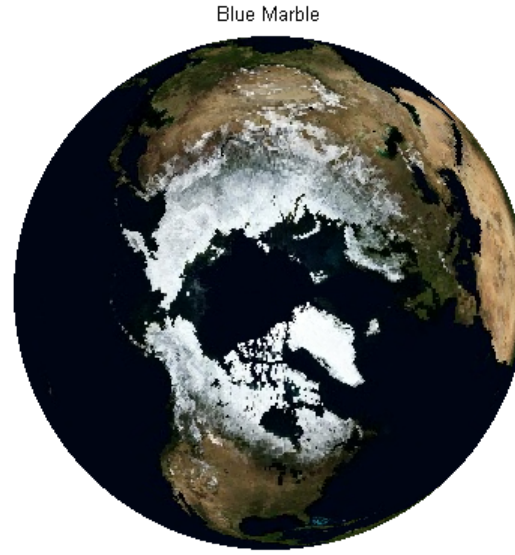
Definitions

The EPSG:4326 coordinate reference system is based on the WGS84 (1984 World Geodetic System) datum. Latitude and longitude are in degrees and longitude is referenced to the Greenwich Meridian.

Examples

Read and display a Blue Marble Next Generation layer from NASA:

```
nasa = wmsfind('nasa', 'SearchField', 'serverurl');
layer = nasa.refine('bluemarbleng', ...
   'SearchField', 'layername', 'MatchType', 'exact');
[A, R] = wmsread(layer(1));
figure
axesm globe
axis off
geoshow(A, R)
title('Blue Marble')
```



Courtesy NASA/JPL-Caltech

Read and display an orthoimage of the northern section of the Golden Gate Bridge in San Francisco, California, using the USGS National Map Seamless server.

Define region of interest.

```
latlim = [37.824928  37.829598];
lonlim = [-122.482373 -122.47768];
```

Find the USGS high-resolution ortho-imagery layer. The USGS National Map provides ortho-imagery from various regions of the United States. One method to obtain the high-resolution ortho-imagery layer is to obtain the capabilities document from the server. The ortho-imagery layer is the only layer from this server. Use multiple attempts to connect to the server in case it is busy.

```
numberOfAttempts = 5;
```

```
attempt = 0;
info = [];
serverURL = 'http://isse.cr.usgs.gov/arcgis/services/Orthoimagery/USGS_ED
while(isempty(info))
    try
        info = wmsinfo(serverURL);
        orthoLayer = info.Layer(1);
    catch e

        attempt = attempt + 1;
        if attempt > numberOfAttempts
            throw(e);
        else
            fprintf('Attempting to connect to server:\n"%s"\n', serverURL
        end
    end
end
```

Obtain the image.

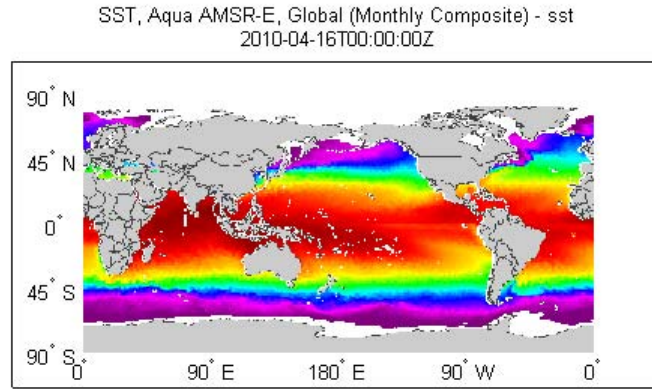
```
imageLength = 1024;
[A, R] = wmsread(orthoLayer, 'Latlim', latlim, 'Lonlim', lonlim, ...
    'ImageHeight', imageLength, 'ImageWidth', imageLength);

% Display the ortho-image in a UTM projection.
figure
axesm('utm', 'Zone', utmzone(latlim, lonlim), ...
    'MapLatlimit', latlim, 'MapLonlimit', lonlim, ...
    'Geoid', wgs84Ellipsoid)
geoshow(A,R)
axis off
title({'San Francisco','Northern Section of Golden Gate Bridge'})
```

San Francisco
Northern Section of Golden Gate Bridge

Read and display a global monthly composite of sea surface temperature for April 16, 2010 based on data from the AMSR-E sensor on board the Aqua satellite. Include the coastline, landmask, and nation layers.

```
coastwatch = wmsfind('coastwatch', 'SearchField', 'serverurl');
layers = coastwatch.refine('erdAAsstamday', ...
   'Searchfield','serverurl');
```

```
time = '2010-04-16T00:00:00Z';
[A, R] = wmsread(layers(end:-1:1), 'Time', time);
figure
axesm('pcarree', 'Maplonlimit', [0, 360], ...
   'PLabelLocation', 45, 'MLabelLocation', 90, ...
   'MLabelParallel', -90, 'MeridianLabel', 'on', ...
   'ParallelLabel', 'on');
geoshow(A, R);
title({layers(end).LayerTitle, time})
```



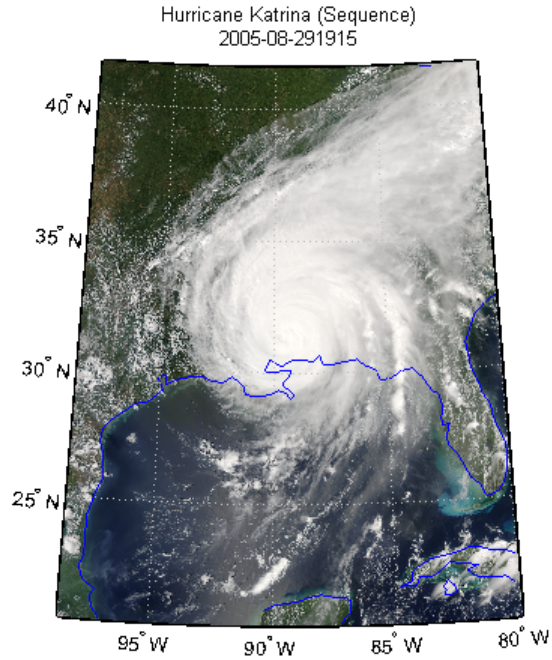
Courtesy NOAA CoastWatch, West Coast Node

Read and display a single sequence image from the MODIS instruments on the Aqua and Terra satellites that shows hurricane Katrina on August 29, 2005:

```
% Find the hurricane Katrina sequence layer.
katrina = wmsfind('Hurricane Katrina (Sequence)');
```

```
katrina = wmsupdate(katrina(1));

% The Dimension.Extent field shows a sequence delimited
% by commas. The sequence starts on August 24 and ends
% on August 31. The commas start at August 25 and end
% after August 30. Select the sequence corresponding to
% August 29.
commas = strfind(katrina.Details.Dimension.Extent, ',');
extent = katrina.Details.Dimension.Extent;
sequence = extent(commas(end-2)+1:commas(end-1)-1);

% Obtain the time, latitude, and longitude limits
% from the values in the sequence. Split the sequence
% into a cell array of values by first finding
% all values between and including the parentheses,
% then remove the parentheses and split the values.
pat = '[(-.\d)]';
r = regexp(sequence, pat);
values = sequence(r);
values = strrep(values, '(', ' ');
values = strrep(values, ')', ' ');
values = regexp(values, '\s', 'split');
values = values(~cellfun('isempty', values));
time = values{1};
xmin = values{2};
ymin = values{3};
xmax = values{4};
ymax = values{5};

% Define latitude and longitude limits from the information
% in the sequence. The layer's geographic extent is assigned
% for the combined set of sequences. The requested map cannot
% be a subset of the layer's bounding box. In this rare case,
% set the layer's limits using the limits of the sequence.
latlim = [str2double(ymin) str2double(ymax)];
lonlim = [str2double(xmin) str2double(xmax)];
katrina.Latlim = latlim;
```

```
katrina.Lonlim = lonlim;

% Read and display the sequence map.
[A,R] = wmsread(katrina, 'SampleDimension', ...
   {katrina.Details.Dimension.Name, sequence});
figure
usamap(katrina.Latlim,katrina.Lonlim);
geoshow(A,R)
coast = load('coast');
plotm(coast.lat, coast.long)
title({katrina.LayerTitle, time})
```



Courtesy NASA/Goddard Space Flight Center Scientific Visualization Studio

See Also

`WebMapServer` | `wmsfind` | `wmsinfo` | `WMSLayer` | `WMSMapRequest` | `wmsupdate`

Purpose

Synchronize WMSLayer object with server

Syntax

```
[updatedLayers, index] = wmsupdate(layers)
[...] = wmsupdate(layers, Name,Value, ...)
```

Description

`[updatedLayers, index] = wmsupdate(layers)` returns a `WMSLayer` array with its properties synchronized with values from the server. The input `layers` contains only one unique `ServerURL`. Layers no longer available on the server are removed. The logical array `index` contains `true` for each available layer. Therefore, `updatedLayers` has the same size as `layers(index)`. Except for deletion, `updatedLayers` preserves the same order of layers as `layers`.

`[...] = wmsupdate(layers, Name,Value, ...)` specifies parameter-value pairs that modify the request. Parameter names can be abbreviated and are case-insensitive.

The function accesses the Internet to update the properties. Periodically, the WMS server is unavailable. Updating the layer can take several minutes. The function times-out after 60 seconds if a connection is not made to the server.

Tips

- To specify a proxy server to connect to the Internet, select **File > Preferences > Web** and enter your proxy information. Use this feature if you have a firewall.

Input Arguments

layers

`WMSLayer` array that contains `WMSLayer` objects.

Name-Value Pair Arguments

Specify optional comma-separated pairs of `Name,Value` arguments, where `Name` is the argument name and `Value` is the corresponding value. `Name` must appear inside single quotes (`' '`). You can specify several name and value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`.

TimeoutInSeconds

Integer-valued, scalar double that indicates the number of seconds before a server times out. A value of `0` causes the time-out mechanism to be ignored.

Default: 60 seconds

AllowMultipleServers

Logical scalar that indicates whether the `layer` array may contain elements from multiple servers. Use caution when setting the value to `true`, since you are making a request to each unique server. Each request can take several minutes to finish.

Default: `false` (indicates the array must contain elements from the same server)

Output Arguments

updatedLayers

`WMSLayer` array with its properties synchronized with values from the server.

index

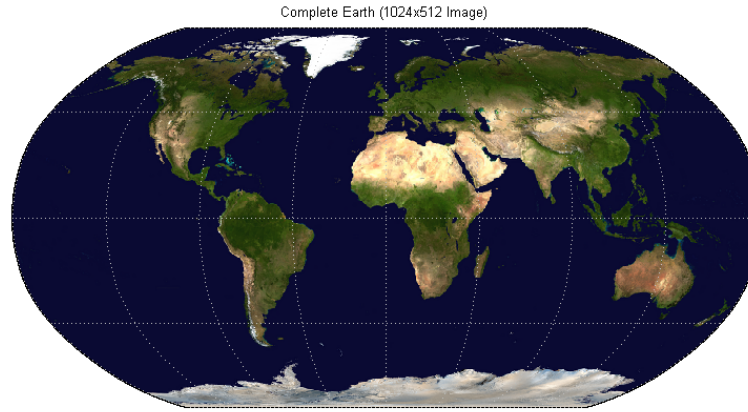
Logical array that contains `true` for each available layer.

Examples

Update the layers from the NASA Goddard Space Flight Center WMS SVS Image Server:

```
% Search the abstract field of the updated layers to find
% layers containing the term 'blue marble'. Read and display
% the first blue marble layer containing the term '512' and
% 'image' in its LayerTitle.
gsfc = wmsfind('svs.gsfc.nasa.gov', 'SearchField', 'serverurl');
gsfc = wmsupdate(gsfc);
blue_marble = gsfc.refine('blue marble', 'SearchField', ...
   'abstract');
queryStr = '*512*image';
layers = blue_marble.refine(queryStr);
```

```
layer = layers(1);

% Display the layer and abstract.
[A, R] = wmsread(layer);
figure
worldmap world
plabel off; mlabel off
geoshow(A, R);
title(layer.LayerTitle)
disp(layer.Abstract)
```



Courtesy NASA/Goddard Space Flight Center Scientific Visualization Studio

Update the properties of all the layers from the NASA servers:

```
nasa = wmsfind('nasa', 'SearchField', 'serverurl');
nasa = wmsupdate(nasa, 'AllowMultipleServers', true);
```

See Also

WebMapServer | wmsfind | wmsinfo | WMSLayer | wmsread

worldFileMatrixToRefmat

Purpose

Convert world file matrix to referencing matrix

Syntax

```
refmat = worldFileMatrixToRefmat(W)
```

Description

`refmat = worldFileMatrixToRefmat(W)` converts the 2-by-3 world file matrix `W` to a 3-by-2 referencing matrix `refmat`.

Definitions

Referencing Matrix

See `makerefmat`.

World File Matrix for Planar System

See `spatialref.MapRasterReference.worldFileMatrix`.

World File Matrix for Geographic System

See `spatialref.GeoRasterReference.worldFileMatrix`.

See Also

`refmatToWorldFileMatrix`

Purpose

Read world file and return referencing object or matrix

Syntax

```
R = worldfileread(worldFileName, coordinateSystemType,
   rasterSize)
refmat = worldileread(worldFileName)
```

Description

`R = worldfileread(worldFileName, coordinateSystemType, rasterSize)` reads the world file, `worldFileName`, and constructs a spatial referencing object, `R`. The type of referencing object is determined by the `coordinateSystemType` string, which can be either `'planar'` (including projected map coordinate systems) or `'geographic'` (for latitude-longitude systems). The `rasterSize` input should match the size of the image corresponding to the world file.

`refmat = worldileread(worldFileName)` reads the world file, `worldFileName`, and constructs a 3-by-2 referencing matrix, `refmat`.

Examples

Read an ortho image referenced to a projected coordinate system (Massachusetts State Plane Mainland).

```
filename = 'concord_ortho_w.tif';
[X, cmap] = imread(filename);
worldFileName = getworldfilename(filename);
R = worldfileread(worldFileName, 'planar', size(X))
```

Read an image referenced to a geographic coordinate system.

```
filename = 'boston_ovr.jpg';
RGB = imread(filename);
worldFileName = getworldfilename(filename);
R = worldfileread(worldFileName, 'geographic', size(RGB))
```

See Also

`getworldfilename` | `map2pix` | `pix2map` | `worldfilewrite`

worldfilewrite

Purpose

Write world file from referencing object or matrix

Syntax

```
worldfilewrite(R, worldfilename)
```

Description

`worldfilewrite(R, worldfilename)` calculates the world file entries corresponding to referencing object or matrix `R` and writes them into the file `worldfilename`. The argument `R` can be a `spatialref.MapRasterReference` object, a `spatialref.GeoRasterReference` object, or a 3-by-2 referencing matrix.

Examples

Write out the information from a referencing object for the image file `concord_ortho_w.tif`

```
info = imfinfo('concord_ortho_w.tif');
R = worldfileread('concord_ortho_w.tfw', ...
     'planar', [info.Height info.Width])
worldfilewrite(R, 'concord_ortho_w_test.tfw');
type concord_ortho_w_test.tfw
```

See Also

`getworldfilename` | `map2pix` | `pix2map` | `worldfileread`

Purpose

Construct map axes for given region of world

Syntax

```
worldmap region
worldmap(region)
worldmap
worldmap(latlim, lonlim)
worldmap(Z, R)
h = worldmap(...)
```

Description

`worldmap region` or `worldmap(region)` sets up an empty map axes with projection and limits suitable to the part of the world specified in `region`. `region` can be a string or a cell array of strings. Permissible strings include names of continents, countries, and islands as well as `'World'`, `'North Pole'`, `'South Pole'`, and `'Pacific'`.

`worldmap` with no arguments presents a menu from which you can select the name of a single continent, country, island, or region.

`worldmap(latlim, lonlim)` allows you to define a custom geographic region in terms of its latitude and longitude limits in degrees. `latlim` and `lonlim` are two-element vectors of the form `[southern_limit northern_limit]` and `[western_limit eastern_limit]`, respectively.

`worldmap(Z, R)` derives the map limits from the extent of a regular data grid georeferenced by `R`. `R` can be a `spatialref.GeoRasterReference` object, a referencing vector, or a referencing matrix.

If `R` is a `spatialref.GeoRasterReference` object, its `RasterSize` property must be consistent with `size(Z)`.

If `R` is a referencing vector, it must be a 1-by-3 with elements:

```
[cells/degree northern_latitude_limit western_longitude_limit]
```

If `R` is a referencing matrix, it must be 3-by-2 and transform raster row and column indices to/from geographic coordinates according to:

```
[lon lat] = [row col 1] * R
```

If `R` is a referencing matrix, it must define a (non-rotational, non-skewed) relationship in which each column of the data grid falls along a meridian and each row falls along a parallel.

`h = worldmap(...)` returns the handle of the map axes.

All axes created with `worldmap` are initialized with a spherical Earth model having a radius of 6,371,000 meters.

`worldmap` uses `tightmap` to adjust the axes limits around the map. If you change the projection, or just want more white space around the map frame, use `tightmap` again or `auto axis`

Examples

Example 1

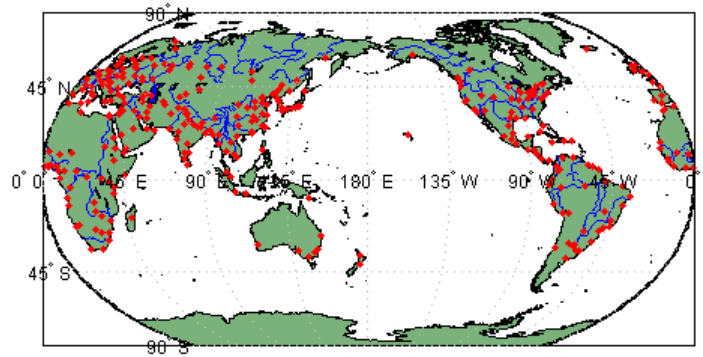
Set up a world map and draw coarse coastlines:

```
worldmap('World')
load coast
plotm(lat, long)
```

Example 2

Set up `worldmap` with land areas, major lakes and rivers, and cities and populated places:

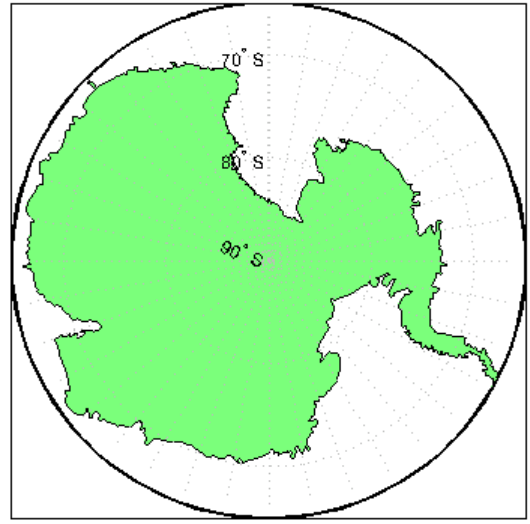
```
ax = worldmap('World');
setm(ax, 'Origin', [0 180 0])
land = shaperead('landareas', 'UseGeoCoords', true);
geoshow(ax, land, 'FaceColor', [0.5 0.7 0.5])
lakes = shaperead('worldlakes', 'UseGeoCoords', true);
geoshow(lakes, 'FaceColor', 'blue')
rivers = shaperead('worldrivers', 'UseGeoCoords', true);
geoshow(rivers, 'Color', 'blue')
cities = shaperead('worldcities', 'UseGeoCoords', true);
geoshow(cities, 'Marker', '.', 'Color', 'red')
```



Example 3

Draw a map of Antarctica:

```
worldmap('antarctica')
antarctica = shaperead('landareas', 'UseGeoCoords', true,...
  'Selector',{@(name) strcmp(name,'Antarctica'), 'Name'});
patchm(antarctica.Lat, antarctica.Lon, [0.5 1 0.5])
```



Example 4

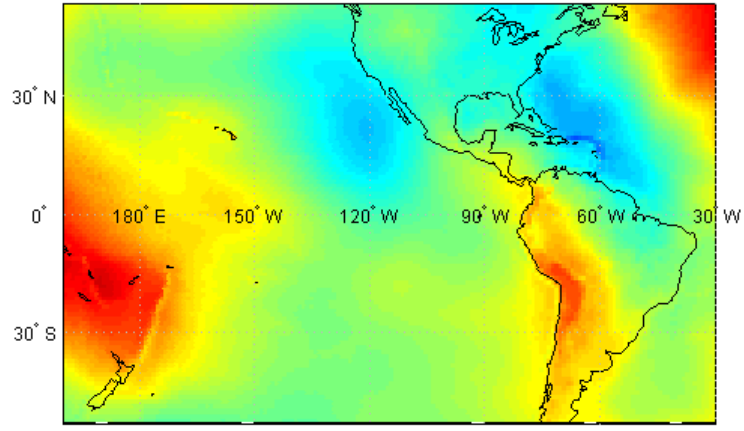
Draw a map of Africa and India with major cities and populated places:

```
worldmap({'Africa','India'})
land = shaperead('landareas.shp', 'UseGeoCoords', true);
geoshow(land, 'FaceColor', [0.15 0.5 0.15])
cities = shaperead('worldcities', 'UseGeoCoords', true);
geoshow(cities, 'Marker', '.', 'Color', 'red')
```

Example 5

Make a map of the geoid over South America and the central Pacific:

```
worldmap([-50 50],[160 -30])
load geoid
geoshow(geoid, geoidrefvec, 'DisplayType', 'texturemap');
load coast
geoshow(lat, long)
```



Example 6

Draw a map of terrain elevations in Korea:

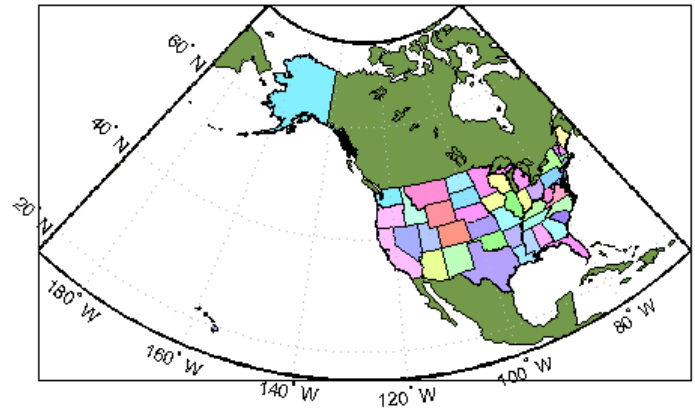
```
load korea
```

```
h = worldmap(map, refvec);
set(h, 'Visible', 'off')
geoshow(h, map, refvec, 'DisplayType', 'texturemap')
demcmap(map)
```

Example 7

Make a map of the United States of America, coloring state polygons:

```
ax = worldmap('USA');
load coast
geoshow(ax, lat, long,...
'DisplayType', 'polygon', 'FaceColor', [.45 .60 .30])
states = shaperead('usastatelo', 'UseGeoCoords', true);
faceColors = makesymbolspec('Polygon',...
    {'INDEX', [1 numel(states)], 'FaceColor', ...
    polcmap(numel(states))}); % NOTE - colors are random
geoshow(ax, states, 'DisplayType', 'polygon', ...
  'SymbolSpec', faceColors)
```



See Also

axesm | framem | geoshow | gridm | mlabel | plabel | tightmap | usamap

wrapTo180

Purpose

Wrap angle in degrees to [-180 180]

Syntax

```
lonWrapped = wrapTo180(lon)
```

Description

`lonWrapped = wrapTo180(lon)` wraps angles in `lon`, in degrees, to the interval `[-180 180]` such that 180 maps to 180 and -180 maps to -180. (In general, odd, positive multiples of 180 map to 180 and odd, negative multiples of 180 map to -180.)

See Also

`wrapTo360` | `wrapTo2Pi` | `wrapToPi`

Purpose

Wrap angle in degrees to [0 360]

Syntax

```
lonWrapped = wrapTo360(lon)
```

Description

`lonWrapped = wrapTo360(lon)` wraps angles in `lon`, in degrees, to the interval `[0 360]` such that 0 maps to 0 and 360 maps to 360. (In general, positive multiples of 360 map to 360 and negative multiples of 360 map to zero.)

See Also

`wrapTo180` | `wrapTo2Pi` | `wrapToPi`

wrapTo2Pi

Purpose

Wrap angle in radians to [0 2*pi]

Syntax

```
lambdaWrapped = wrapTo2Pi(lambda)
```

Description

`lambdaWrapped = wrapTo2Pi(lambda)` wraps angles in `lambda`, in radians, to the interval `[0 2*pi]`, such that 0 maps to 0 and `2*pi` maps to `2*pi`. (In general, positive multiples of `2*pi` map to `2*pi` and negative multiples of `2*pi` map to 0.)

See Also

`wrapTo180` | `wrapTo360` | `wrapToPi`

Purpose

Wrap angle in radians to [−pi pi]

Syntax

```
lambdaWrapped = wrapToPi(lambda)
```

Description

`lambdaWrapped = wrapToPi(lambda)` wraps angles in `lambda`, in radians, to the interval `[ pi pi]`. `pi` maps to `pi` and `pi` maps to `pi`. (In general, odd, positive multiples of `pi` map to `pi` and odd, negative multiples of `pi` map to `pi`.)

See Also

`wrapTo180` | `wrapTo360` | `wrapTo2Pi`

zdatam

Purpose

Adjust *z*-plane of displayed map objects

Syntax

```
zdatam
zdatam(hndl)
zdatam('str')
zdatam(hndl,zdata)
zdatam('str',zdata)
```

Description

`zdatam` displays a GUI for selecting an object from the current axes and modifying its `ZData` property.

`zdatam(hndl)` and `zdatam('str')` display a GUI to modify the `ZData` of the object(s) specified by the input. `str` is any string recognized by `handlem`.

`zdatam(hndl,zdata)` alters the *z*-plane position of displayed map objects designated by the MATLAB graphics handle `hndl`. The *z*-plane position may be the `Z` position in the case of text objects, or the `ZData` property in the case of other graphic objects. The function behaves as follows:

- If `hndl` is an `hggroup` handle, the `ZData` property of the children in the `hggroup` are altered.
- If the handle is scalar, then `ZData` can be either a scalar (*z*-plane definition), or a matrix of appropriate dimension for the displayed object.
- If `hndl` is a vector, then `ZData` can be a scalar or a vector of the same dimension as `hndl`.
- If `ZData` is a scalar, then all objects in `hndl` are drawn on the `ZData` *z*-plane.
- If `ZData` is a vector, then each object in `hndl` is drawn on the plane defined by the corresponding `ZData` element.
- If `ZData` is omitted, then a modal dialog box prompts for the `ZData` entry.

`zdatam('str',zdata)` identifies the objects by the input `str`, where `str` is any string recognized by `handelm`, and uses `zdata` as described above to update their `ZData` property.

This function adjusts the *z*-plane position of selected graphics objects. It accomplishes this by setting the objects' `ZData` properties to the appropriate values.

See Also

`handlem | setm`

zero22pi

Purpose

Wrap longitudes to [0 360] degree interval

Note The `zero22pi` function has been replaced by `wrapTo360` and `wrapTo2Pi`.

Syntax

```
newlon = zero22pi(lon)
newlon = zero22pi(lon,angleunits)
```

Description

`newlon = zero22pi(lon)` *wraps* the input angle `lon` in degrees to the 0 to 360 degree range.

`newlon = zero22pi(lon,angleunits)` works in the units defined by the string `angleunits`, which can be either `'degrees'` or `'radians'`. `angleunits` can be abbreviated and is case-insensitive.

Examples

```
zero22pi(567.5)

ans =
    207.5

zero22pi(-567.5)

ans =
    152.5

zero22pi(-7.5,'radian')

ans =
    5.0664
```

See Also

`wrapTo2Pi` | `wrapTo360`

Purpose

Construct regular data grid of 0s

Syntax

```
[Z,refvec] = zerom(latlim,lonlim,scale)
```

Description

`[Z,refvec] = zerom(latlim,lonlim,scale)` returns a full regular data grid consisting entirely of `0`s and a three-element referencing vector for the returned `Z`. The two-element vectors `latlim` and `lonlim` define the latitude and longitude limits of the geographic region. They should be of the form `[south north]` and `[west east]`, respectively. The scalar `scale` specifies the number of rows and columns per degree of latitude and longitude.

Examples

```
[Z,refvec] = zerom([46,51],[-79,-75],1)

Z =
     0     0     0     0
     0     0     0     0
     0     0     0     0
     0     0     0     0
     0     0     0     0
refvec =
     1    51   -79
```

See Also

`limitm` | `nanm` | `onem` | `sizem` | `spzerom`

Purpose

Define map axes and modify map projection and display properties

Activation

Command Line	Maptool	Map Display

`axesmui`
 	
`c = axesmui(...)`
	Display > Projection	`extend-click map display`

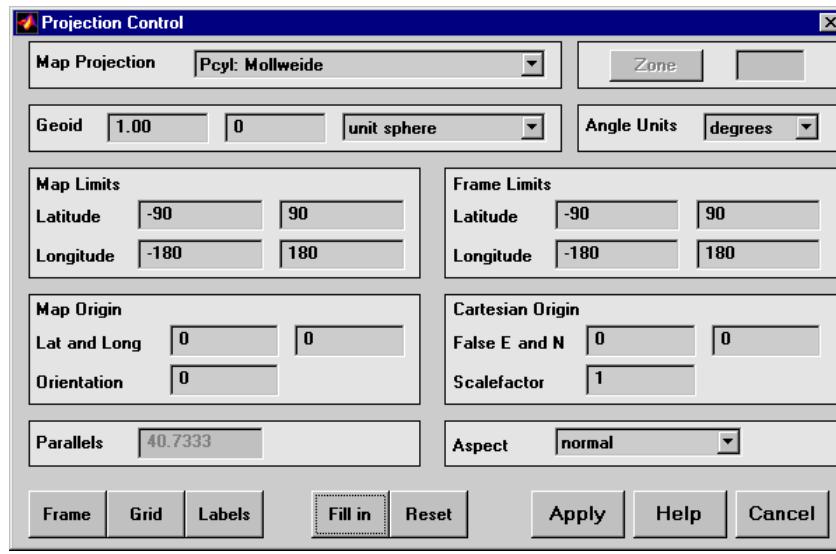
Description

`axesmui` activates a Projection Control dialog box for the current map axes. The dialog box allows map projection definition and property modification.

`c` is an optional output argument that indicates whether the Projection Control dialog box was closed by the cancel button. `c = 1` if the cancel button is pushed. Otherwise, `c = 0`.

Extend-clicking a map display brings up the Projection Control dialog box for that map axes.

Controls



The **Map Projection** pull-down menu is used to select a map projection. The projections are listed by type, and each is preceded by a four-letter type indicator:

```
Cyln = Cylindrical
Pcyl = Pseudocylindrical
Coni = Conic
Poly = Polyconic
Pcon = Pseudoconic
Azim = Azimuthal
Mazi = Modified Azimuthal
Pazi = Pseudoazimuthal
```

The **Zone** button and edit box are used to specify the UTM or UPS zone. For non-UTM and UPS projections, the two are disabled.

The **Geoid** edit boxes and pull-down menu are used to specify the geoid. Units must be in meters for the UTM and UPS projections, since this is the standard unit for the two projections. For non-UTM and UPS projections, the geoid unit can be anything, bearing in mind that the resulting projected data will be in the same units as the geoid.

The **Angle Units** pull-down menu is used to specify the angle units used on the map projection. All angle entries corresponding to the current map projection must be entered in these units. Current angle entries are automatically updated when new angle units are selected.

The **Map Limits** edit boxes are used to specify the extent of the map data in geographic coordinates. The **Latitude** edit boxes contain the southern and northern limits of the map. The **Longitude** edit boxes contain the western and eastern limits of the map. The map limits establish the extent of the meridian and parallel grid lines, regardless of the display settings (see grid settings). Map limits are always in geographic coordinates, regardless of the map origin and orientation setting. In the normal aspect, the map display is trimmed to the minimum of the map and frame limits.

The **Frame Limits** edit boxes are used to specify the location of the map frame, measured from the center of the map projection in the base

coordinate system. The **Latitude** edit boxes contain the southern and northern frame edge locations. The **Longitude** edit boxes contain the western and eastern frame edge locations. Displayed map data are trimmed at the frame limits. For azimuthal map projections, the latitude limits should be set to `inf` and the desired trim distance from the map origin. In the normal aspect, the map display is trimmed to the minimum of the map and frame limits.

The **Map Origin** edit boxes are used to specify the origin and aspect angle of the map projection. The **Lat** and **Long** boxes specify the map origin in geographic coordinates. This is the point that is placed in the center of the projection. If either box is left blank, 0 degrees is used. The **Orientation** box specifies the azimuth angle of the North Pole relative to the map origin. Azimuth is measured clockwise from the top of the projection. If the **Orientation** box is disabled, then the selected map projection requires a fixed orientation. See the *Mapping Toolbox User's Guide* for a complete description of the map origin.

The **Cartesian Origin** edit boxes are used to specify the *x-y* offset, along with a desired scale factor of the map projection. The **False E and N** boxes specify the false easting and northing in Cartesian coordinates. These must be in the same units as the geoid. The **Scalefactor** box specifies the scale factor used in the map projection calculations.

The **Parallels** edit boxes specify the standard parallels of the selected map projection. A particular map projection may have one or two standard parallels. If the edit boxes are disabled, then the selected projection has no standard parallels or the standard parallels are fixed.

The **Aspect** pull-down menu is used to select a normal or transverse display aspect. When the aspect is normal, *north* (on the base projection) is up, and the map is displayed in a *portrait* setting. In a transverse aspect, north (in the base projection) is to the right, and the map is displayed in a *landscape* setting. This property does not control the map projection aspect. The projection aspect is determined by the map `Origin` property).

The **Frame** button brings up the Map Frame Properties dialog box, which allows the map frame settings to be modified.

The **Grid** button brings up the Map Grid Properties dialog box, which allows the map grid settings to be modified.

The **Labels** button brings up the Map Label Properties dialog box, which allows the parallel and meridian label settings to be modified.

The **Fill in** button is used to compute projection and display settings based on any currently specified map parameters. Only settings that are left blank are affected when this button is pushed.

The **Reset** button is used to reset the default projection properties and display settings of the current map. Default display settings include frame, grid, and label properties set to `'off'`.

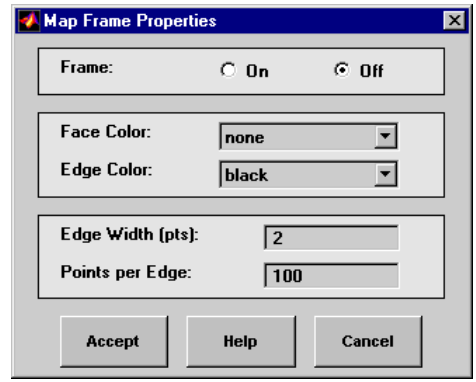
The **Apply** button is used to apply the projection and display settings to the current map, which results in the map being reprojected.

The **Help** button is used to bring up online help text for each control on the Projection Control dialog box.

The **Cancel** button disregards any modified projection or display settings and closes the Projection Control dialog box.

Map Frame Properties Dialog Box

This dialog box allows modification of the map frame settings. It is accessed via the **Frame** button on the Projection Control dialog box.



The **Frame** selection buttons determine whether the map frame is visible.

The **Face Color** pull-down menu is used to select the background color of the map frame. Selecting `none` results in a transparent frame background, i.e., the same as the axes color. Selecting `custom` allows a custom RGB triple to be defined for the background color.

The **Edge Color** pull-down menu is used to select the color of the frame edge. Selecting `none` hides the frame edge. Selecting `custom` allows a custom RGB triple to be defined for the edge color.

The **Edge Width** edit box is used to enter the line width of the frame edge, in points.

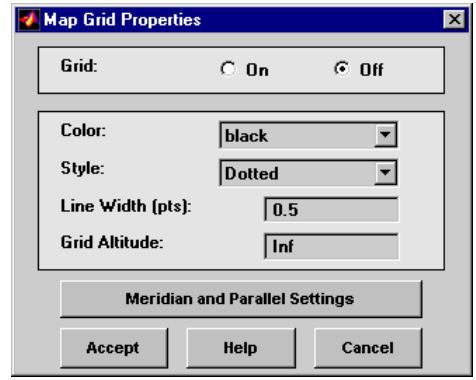
The **Points per Edge** edit box is used to enter the number of points used to display each edge of the map frame.

The **Accept** button accepts any modifications made to the map frame properties and returns to the Projection Control dialog box. Changes are applied to the current map only when the **Apply** button on the Projection Control dialog box is pushed.

The **Cancel** button disregards any modifications to the map frame properties and returns to the Projection Control dialog box.

Map Grid Properties Dialog Box

This dialog box allows modification of the map frame settings. It is accessed via the **Grid** button on the Projection Control dialog box.



The Grid selection buttons determine whether the map grid is visible.

The **Color** pull-down menu is used to select the color of the map grid lines. Selecting `custom` allows a custom RGB triple to be defined for the grid line color.

The **Style** pull-down menu is used to select the line style of the map grid lines.

The **Line Width** edit box is used to enter the width of the map grid lines, in points.

The **Grid Altitude** edit box is used to enter *z*-axis location of the map grid. This property can be used to place some mapped objects above or below the map grid. The default map grid altitude is `inf`, which places the grid above all other mapped objects.

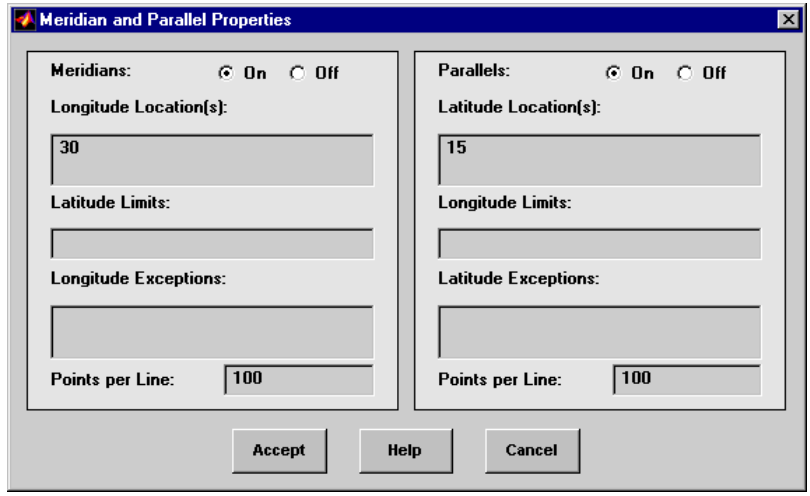
The **Meridian and Parallel Settings** button brings up the **Meridian and Parallel Properties** dialog box, which allows the properties of the meridian and parallel grid lines to be modified.

The **Accept** button accepts any modifications made to the map grid properties and returns to the Projection Control dialog box. Changes are applied to the current map only when the **Apply** button on the Projection Control dialog box is pushed.

The **Cancel** button disregards any modifications to the map grid properties and returns to the Projection Control dialog box.

Meridian and Parallel Properties Dialog Box

This dialog box is used to modify the settings for meridian and parallel grid lines. It is accessed via the **Meridian and Parallel Settings** button on the Map Grid Properties dialog box.



The **Meridians** selection buttons determine whether the meridian grid lines are visible when the map grid is turned on.

The **Longitude Location(s)** edit box is used to specify which meridians are to be displayed if the meridian lines are turned on. If a scalar interval value is entered, meridian lines are displayed at that interval, starting from the Prime Meridian and proceeding in east and west directions. If a vector of values is entered, meridian lines are displayed at locations given by each element of the vector.

The **Latitude Limits** edit box is used to specify the latitude limits beyond which meridian lines do not extend. If this property is left empty, all meridian lines extend to the map latitude limits (specified by the Latitude Map Limits entry on the **Projection Control** dialog box). This entry must be a two-element vector enclosed in brackets.

The **Longitude Exceptions** edit box is used to enter specific meridians of the displayed grid that are to extend beyond the latitude limits, to the map limits. This entry is a vector of longitude values.

The **Parallels** selection buttons determine whether the parallel grid lines are visible when the map grid is turned on.

The **Latitude Location(s)** edit box is used to specify which parallels are to be displayed if the parallel lines are turned on. If a scalar interval value is entered, parallel lines are displayed at that interval, starting from the Equator and proceeding in north and south directions. If a vector of values is entered, parallel lines are displayed at locations given by each element of the vector.

The **Longitude Limits** edit box is used to specify the longitude limits beyond which parallel lines do not extend. If this property is left empty, all parallel lines extend to the map longitude limits (specified by the Longitude Map Limits entry on the **Projection Control** dialog box). This entry must be a two-element vector enclosed in brackets.

The **Latitude Exceptions** edit box is used to enter specific parallels of the displayed grid that are to extend beyond the longitude limits, to the map limits. This entry is a vector of latitude values.

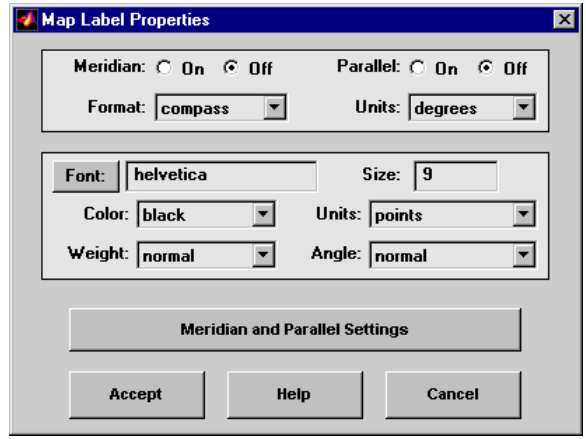
The **Points per Line** edit boxes are used to enter the number of points used to plot each meridian and each parallel grid line. The default value is 100 points.

The **Accept** button accepts any modifications that have been made to the meridian and parallel grid line properties and return to the Map Grid Properties dialog box. Changes are applied to the current map only when the **Apply** button on the Projection Control dialog box is pushed.

The **Cancel** button disregards any modifications to the meridian and parallel grid lines and returns to the Map Grid Properties dialog box.

Map Label Properties Dialog Box

This dialog box is used to modify the settings of the meridian and parallel labels. It is accessed via the **Label** button on the Projection Control dialog box.



The **Meridian** and **Parallel** selection buttons determine whether the meridian and parallel labels are visible.

The **Format** pull-down menu is used to specify the format of the grid labels. If `compass` is selected, meridian labels are appended with `E` for east and `W` for west, and parallel labels are appended with `N` for north and `S` for south. If `signed` is chosen, meridian labels are prefixed with `+` for east and `-` for west, and parallel labels are prefixed with `+` for north and `-` for south. If `none` is selected, western meridian labels and southern parallel labels are prefixed by `-`, but no symbol precedes eastern meridian labels and northern parallel labels.

The label **Units** pull-down menu is used to specify the angle units used to display the parallel and meridian labels. These units, used for display purposes only, need not be the same as the angle units of the map projection.

The **Font** edit box is used to specify the character font used to display the parallel and meridian labels. If the font specified does not exist on the computer, the default of `Helvetica` is used. Pressing the **Font** button previews the selected font.

The font **Size** edit box is used to enter an integer value that specifies the font size of the parallel and meridian labels. This value must be in the units specified by the font **Units** pull-down menu.

The font **Color** pull-down menu is used to select the color of the parallel and meridian labels. Selecting `custom` allows a custom RGB triple to be defined for the labels.

The font **Weight** pull-down menu is used to specify the character weight of the parallel and meridian labels.

The font **Units** pull-down menu is used to specify the units used to interpret the font size entry. When set to `normalized`, the value entered in the **Size** edit box is interpreted as a fraction of the height of the axes. For example, a normalized font size of 0.1 sets the label text to a height of one tenth of the axes height.

The font **Angle** pull-down menu is used to select the character slant of the parallel and meridian labels. `normal` specifies nonitalic font. `italic` and `oblique` specify italic font.

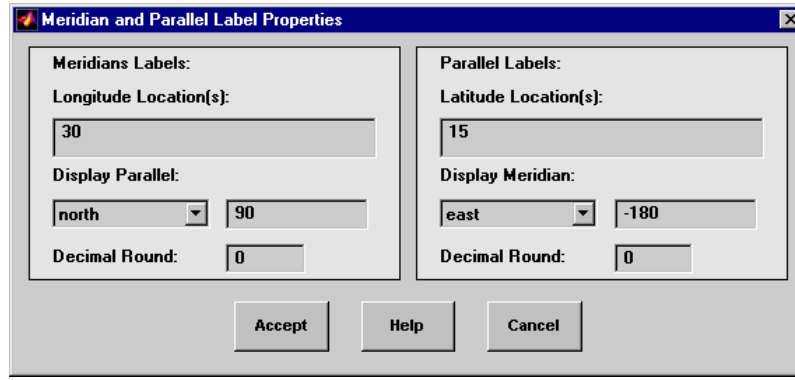
The **Meridian and Parallel Settings** button brings up the Meridian and Parallel Label Properties dialog box, which allows modification of properties specific to the meridian and parallel grid labels.

The **Accept** button accepts any modifications that have been made to the map label properties and returns to the Projection Control dialog box. Changes are applied to the current map only when the **Apply** button on the Projection Control dialog box is pushed.

The **Cancel** button disregards any modifications to the map labels and returns to the **Projection Control** dialog box.

Meridian and Parallel Label Properties Dialog Box

This dialog box is used to modify properties specific to the meridian and parallel grid labels. It is accessed via the **Meridian and Parallel Settings** button on the Map Label Properties dialog box.



The **Longitude Location(s)** edit box is used to specify which meridians are to be labeled. Meridian labels need not coincide with displayed meridian grid lines. If a scalar interval value is entered, labels are displayed at that interval, starting from the Prime Meridian and proceeding in east and west directions. If a vector of values is entered, labels are displayed at longitude locations given by each element of the vector.

The **Display Parallel** pull-down menu and edit box are used to specify the latitude location of the meridian labels. If a scalar latitude value is provided in the edit box, the meridian labels are placed at that parallel. Alternatively, the pull-down menu can be used to select a latitude location. If `north` is chosen, meridian labels are placed at the maximum map latitude limit. If `south` is chosen, meridian labels are placed at the minimum map latitude limit.

The **Latitude Location(s)** edit box is used to specify which parallels are to be labeled. Parallel labels need not coincide with displayed parallel grid lines. If a scalar interval value is entered, labels are displayed at that interval, starting from the Equator and proceeding in north and south directions. If a vector of values is entered, labels are displayed at latitude locations given by each element of the vector.

The **Display Meridian** pull-down menu and edit box are used to specify the longitude location of the parallel labels. If a scalar longitude value is provided in the edit box, the parallel labels are placed at that

meridian. Alternatively, the pull-down menu can be used to specify a longitude location. If `east` is chosen, parallel labels are placed at the maximum map longitude limit. If `west` is chosen, parallel labels are placed at the minimum map longitude limit.

The **Decimal Round** edit boxes are used to specify the power of ten to which the meridian and parallel labels are rounded. For example, a value of -1 results in labels displayed to the tenths decimal place.

The **Accept** button accepts any modifications that have been made to the meridian and parallel label properties and return to the Map Label Properties dialog box. Changes are applied to the current map only when the **Apply** button on the **Projection Control** dialog box is pushed.

The **Cancel** button disregards any modifications to the meridian and parallel labels and returns to the Map Label Properties dialog box.

The **Map Geoid** edit box is used to specify the geoid (ellipsoid) definition for the current map axes. The geoid is defined by a two-element vector of the form `[semimajor-axis eccentricity]`. Eccentricity must be a value between 0 and 1, but not equal to 1. A nonzero eccentricity represents an ellipsoid. The default geoid is a sphere with radius 1, represented as `[1 0]`. If a scalar entry is provided, it is assumed to be the radius of a sphere.

The **Accept** button accepts any modifications that have been made to the map geoid and return to the Projection Control dialog box. Changes are applied to the current map only when the **Apply** button on the Projection Control dialog box is pushed.

The **Cancel** button disregards any modifications to the map geoid and returns to the Projection Control dialog box.

See Also

`axesm`

Purpose

GUI to clear mapped objects

Activation

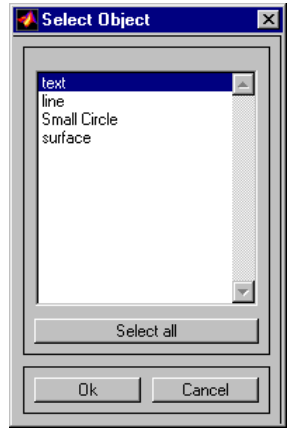
Command Line	Maptool
`clmo`	**Tools > Delete > Object**

Description

`clmo` brings up a Select Object dialog box for selecting mapped objects to delete.

Controls

The scroll box is used to select the desired objects from the list of mapped objects.



Pushing the **Select all** button highlights all objects in the scroll box for selection. Pushing the **OK** button deletes the selected objects from the map. Pushing the **Cancel** button aborts the operation.

See Also

`clmo`

Purpose

Add colormap menu to figure window

Activation

Command Line
`clrmenu`
`clrmenu(h)`

Description

`clrmenu` adds a colormap menu to the current figure.

`clrmenu(h)` adds a colormap menu to the figure specified by the handle `h`.

Controls

The following choices are included on the colormap menu:

Gray, **Hsv**, **Hot**, **Pink**, **Cool**, **Bone**, **Jet**, **Copper**, **Spring**, **Summer**, **Autumn**, **Winter**, **Flag**, and **Prism** generate colormaps.

Rand is a random colormap.

Brighten increases the brightness.

Darken decreases the brightness.

Flipud inverts the order of the colormap entries.

Fliplr interchanges the red and blue components.

Permute permutes the colormap: red > blue, blue > green, green > red.

Spin spins the colormap.

Define allows a workspace variable to be specified for the colormap.

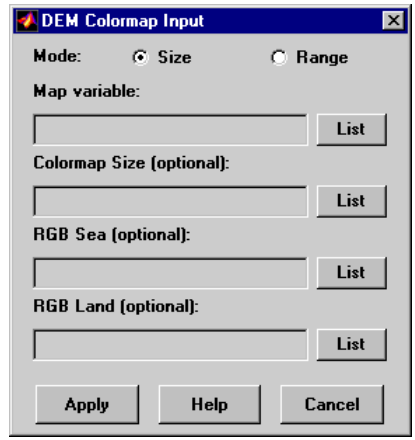
Remember stores the current colormap.

Restore reverts to the stored colormap (initially, the stored colormap is the colormap in use when `clrmenu` is invoked).

Refresh redraws the current figure window.

Digital Elevation activates the DEM Colormap Input dialog box. Use it to specify a colormap for a digital elevation map, and then apply the

colormap to the current figure. The number of land and sea colors in the colormap is appropriate for the maximum elevations and depths of the data grid. The dialog box is shown and described below:



The **Mode** selection buttons are used to specify whether the length of the colormap is specified or whether the altitude range increment assigned to each color is specified.

The **Map variable** edit box is used to specify the data grid containing the elevation data.

The **Colormap Size** edit box is used in Size mode. This entry defines the length of the colormap. If omitted, a default length of 64 is used. This entry must be a scalar value.

The **Altitude Range** edit box is used in Range mode. This entry defines the altitude range increment assigned to each color. If omitted, a default increment of 100 is used. This entry must be a scalar value.

The **RGB Sea** edit box is used to define colors for data with negative values. The actual sea colors of the generated colormap are interpolated from this matrix. This entry can be a matrix of any length (n by 3). The colormap matrix of the current figure can be used by entering the string `'window'` in this box. The `demcmap` function provides default sea colors, which are used if this entry is left blank.

The **RGB Land** edit box is used to define colors for data with positive values. The actual land colors of the generated colormap are interpolated from this matrix. This entry can be a matrix of any length (n by 3). The colormap matrix of the current figure can be used by entering the string `'window'` in this box. The `demcmap` function provides default sea colors, which are used if this entry is left blank.

Pressing the **Apply** button accepts the input data, creates the colormap, and assigns it to the current figure.

Pressing the **Cancel** button disregards any input data and closes the DEM Colormap Input dialog box.

See Also

`colorm` | `demcmap`

colorm

Purpose

Create index map colormaps

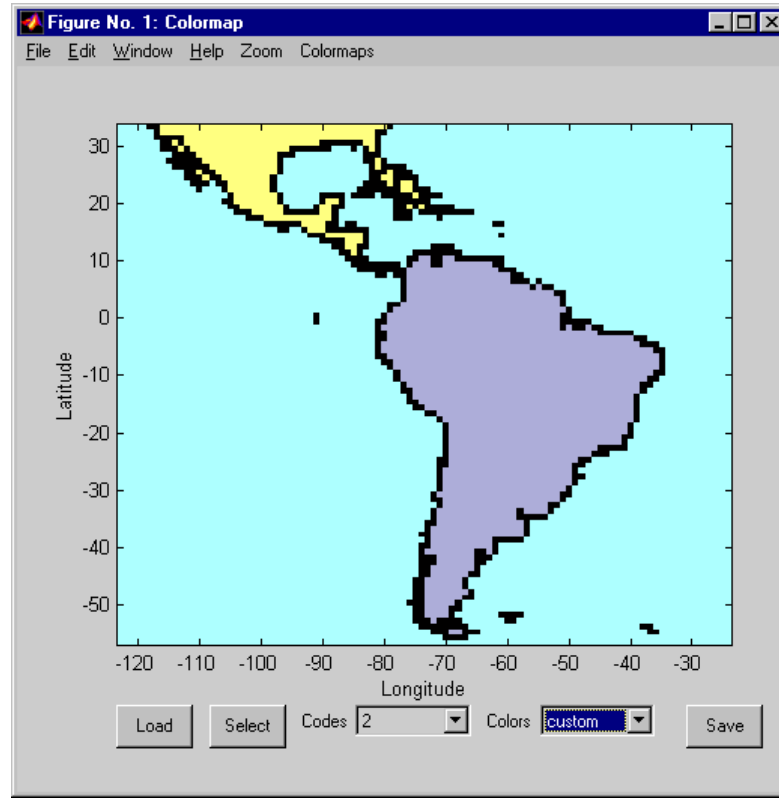
Activation

Command Line
`colorm(datagrid,refvec)`

Description

`colorm(datagrid,refvec)` displays the data grid in a new figure window and allows a colormap to be edited and saved to a new variable. `datagrid` and `refvec` are the data grid and the referencing vector of the surface. `map` must have positive index values into the colormap.

Controls



The `colorm` tool displays the surface map data in a new figure window with the current colormap. **Zoom** and **Colormaps** menus are activated for that figure.

The **Zoom On/Off** menu toggles the `panzoom` box on and off. The box can be moved by clicking the new location or by dragging the box to the new location. The box size can be increased or decreased by dragging a corner of the box. Pressing the `Return` key or double-clicking in the center of the box zooms in.

The **Colormaps** menu provided a variety of colormap options that can be applied to the map. See `clrmenu` in this guide for a description of the **Colormaps** menu options.

The **Load** button activates a dialog box, used to specify a colormap variable to be applied to the displayed surface map. This colormap can then be edited and saved.

The **Select** button activates the mouse cursor and allows a point on the map to be selected. The value of that point then appears in the **Codes** pull-down menu. The color of the selected point appears in the **Color** pull-down menu and can then be edited.

The **Codes** pull-down menu is used to select a particular value in the data grid. The color associated with that value then appears in the **Color** pull-down menu and can be edited.

The **Color** pull-down menu is used to select a particular color to assign to the value currently displayed in the Codes pull-down menu. A custom color can be defined by selecting the `custom` option. This brings up a custom color interface with which an RGB triple can be selected.

The **Save** button is used to save the modified colormap to the workspace. A dialog box appears in which the colormap variable name is entered.

See Also

`encodem` | `getseeds` | `maptrim` | `panzoom` | `seedm`

Purpose

UI for selecting digital elevation data

Activation

```
demdataui
```

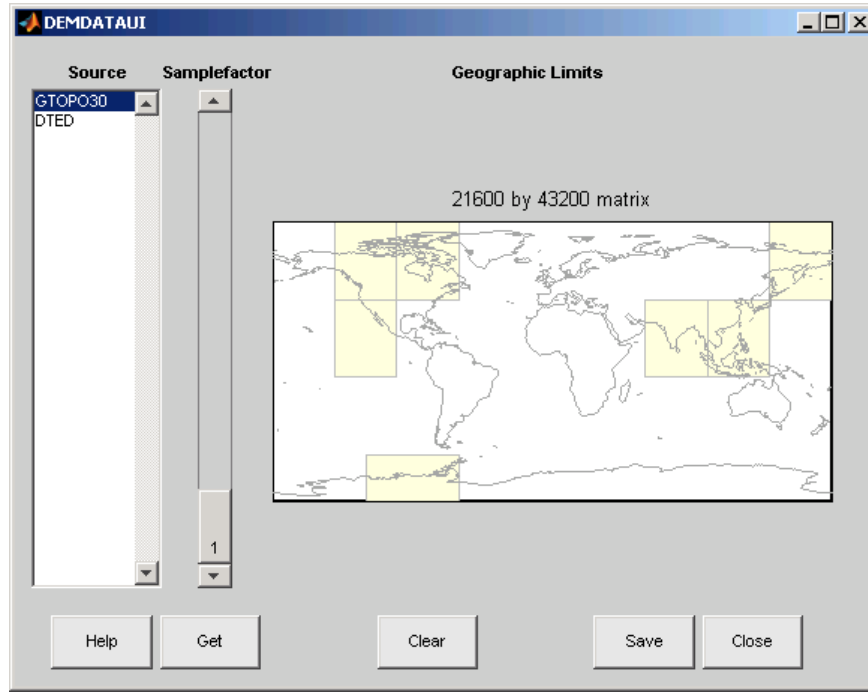
Description

`demdataui` is a graphical user interface to extract digital elevation map data from a number of external data files. You can extract data to MAT-files or the base workspace as regular data grids with referencing vectors.

The `demdataui` panel lets you read data from a variety of high-resolution digital elevation maps (DEMs). These DEMs range in resolution from about 10 kilometers to 100 meters or less. The data files are available over the Internet at no cost, or (in some cases) on CD-ROMs for varying fees. `demdataui` reads ETOPO5, TerrainBase, GTOPO30, GLOBE, satellite bathymetry, and DTED data. See the links under See Also for more information on these data sets. `demdataui` looks for these geospatial data files on the MATLAB path and, for some operating systems, on CD-ROM disks.

You use the list to select the source of data and the map to select the region of interest. When you click the **Get** button, data is extracted and displayed on the map. Use the **Save** button to save the data in a MAT-file or to the base workspace for later display. The **Close** button closes the window.

Controls



The Map

The map controls the geographic extent of the data to be extracted. `demdataui` extracts data for areas currently visible on the map. Use the mouse to zoom in or out to the area of interest. See `zoom` for more on zooming.

Some data sources divide the world up into tiles. When extracting, data is concatenated across all visible tiles. The map shows the tiles in light yellow with light gray edges. When data resolution is high, extracting data for large area can take much time and memory. An approximate count of the number of points is shown above the map. Use the **Samplefactor** slider to reduce the amount of data.

The List

The list controls the source of data to be extracted. Click a name to see the geographic coverage in light yellow. The sources list shows the data sources found when `demdataui` started.

`demdataui` searches for data files on the MATLAB path. On some computers, `demdataui` also checks for data files on the root level of letter drives. `demdataui` looks for the following data: `etopo5`: `new_etopo5.bil` or `etopo5.northern.bat` and `etopo5.southern.bat` files. `tbase`: `tbase.bin` file. `satbath`: `topo_6.2.img` file. `gtopo30`: a folder that contains subfolders with the data files. For example, `demdataui` would detect `gtopo30` data if a folder on the path contained the folders E060S10 and E100S10, each of which holds the uncompressed data files. `globedem`: a folder that contains data files and in the subfolder `/esri/hdr` and the `*.hdr` header files. `dted`: a folder that has a subfolder named DTED. The contents of the DTED folder are more subfolders organized by longitude and, below that, the DTED data files for each latitude tile. See the help for functions with the data source names for more on the data attributes and internet locations.

The Samplefactor Slider

The **Sample Factor** slider allows you to reduce the density of the data. A sample factor of 2 returns every second point. The current sample factor is shown on the slider.

The Get Button

The **Get** button reads the currently selected data and displays it on the map. Press the standard interrupt key combination for your platform to interrupt the process.

The Clear Button

The **Clear** button removes any previously read data from the map.

The Save Button

The **Save** button saves the currently displayed data to a MAT-file or the base workspace. If you choose to save to a file, you will be prompted for

a file name and location. If you choose to save to the base workspace, you can choose the variable name under which the data will be stored.

Data are returned as Mapping Toolbox Version 1 display structures. For information about display structure format, see "Version 1 Display Structures" on page 3-177 in the reference page for `displaym`.

Use `load` and `displaym` to redisplay the data from a file on a map axes. To display the data in the base workspace, use `displaym`. To gain access to the data matrices, subscript into the structure (for example, `datagrid = demdata(1).map; refvec = demdata(1).maplegend`). Use `worldmap` to create easy displays of the elevation data (for example, `worldmap(datagrid,refvec)`). Use `meshm` to add regular data grids to existing displays, or `surfm` or a similar function for geolocated data grids (for example, `meshm(datagrid,refvec)` or `surfm(latgrat,longrat,z)`).

The Close Button

The **Close** button closes the `demdataui` panel.

See Also

`etopo` | `tbase` | `gtopo30` | `globedem` | `dted` | `satbath` | `vmap0ui`

Purpose

GUI for handles of specified mapped objects

Activation

Command Line
`h = handlem`
`h = handlem('prompt')`

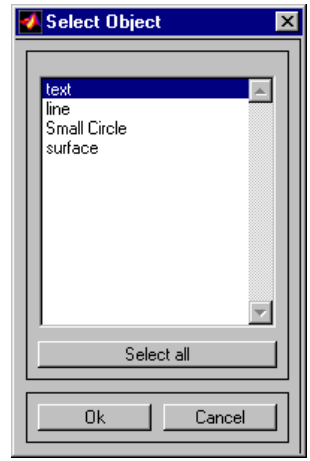
Description

`h = handlem` brings up a Select Object dialog box, which lists all currently displayed objects. Objects can be selected and their handles returned.

`h = handlem('prompt')` brings up a Specify Object dialog box, which allows greater control of object selection.

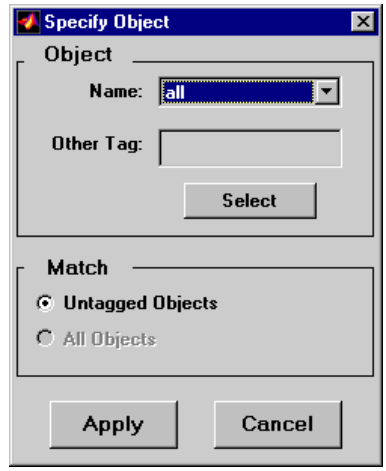
Controls

Select Object Dialog Box



The scroll box is used to select the desired objects from the list of mapped objects. Pushing the **Select all** button highlights all objects in the scroll box for selection. Pushing the **OK** button returns the object handles in the variable `h`. Pushing the **Cancel** button aborts the operation.

Specify Object Dialog Box



The **Object** Controls are used to select an object type or tag. The **Name** pull-down menu is used to select from a list of predefined object strings. The **Other Tag** edit box is used to specify an object tag not listed in the **Name** pull-down menu. Pushing the **Select** button brings up the Select Object dialog box, which shows only the currently displayed objects for selection.

The **Match** Controls are used when a Handle Graphics object type (image, line, surface, patch, or text) is specified. The **Untagged Objects** selection button is used to return the handles of only those objects with empty tag properties. The **All Objects** selection button is used to return all object handles of the specified type, regardless of whether they are tagged.

Pushing the **Apply** button returns the handles of the specified objects. Pushing the **Cancel** button aborts the operation.

See Also

`handlem`

Purpose

Hide specified mapped objects

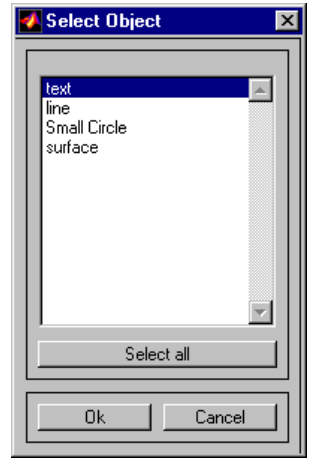
Activation

Command Line	Maptool
`hidem`	**Tools > Hide > Object**

Description

`hidem` brings up a Select Object dialog box for selecting mapped objects to hide (`Visible` property set to `'off'`).

Controls



The scroll box is used to select the desired objects from the list of mapped objects. Pushing the **Select all** button highlights all objects in the scroll box for selection. Pushing the **OK** button changes the `Visible` property of the selected objects to `'off'`. Pushing the **Cancel** button aborts the operation without changing any properties of the selected objects.

See Also

`hidem`

lightmui

Purpose

Control position of lights on globe or 3-D map

Syntax

```
lightmui(hax)
```

Description

`lightmui(hax)` creates a GUI to control the position of lights on a globe or 3-D map in map axes `hax`. You can control the position of lights by clicking and dragging the icon or by dialog boxes. Right-click the appropriate icon in the GUI to invoke the corresponding dialog box. You can change the light color by entering the RGB components manually or by clicking the pushbutton.

See Also

`lightm`

Purpose

Add menu-activated tools to map figure

Activation

Command Line
`maptool(`*`PropertyName`*`,PropertyValue)`
`maptool(`*`ProjectionFile`*`,...)`
`h = maptool(...)`

Description

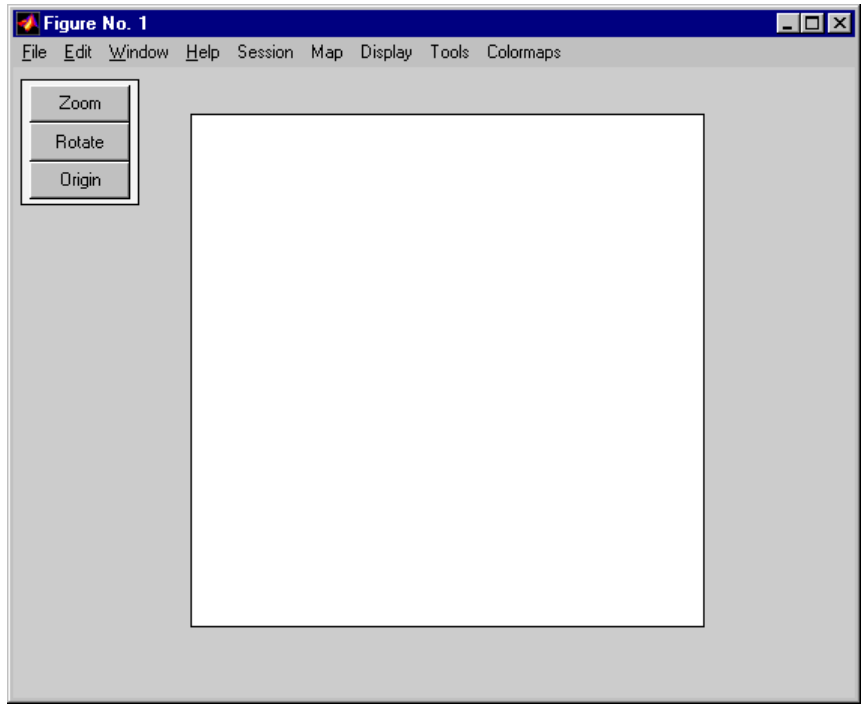
`maptool` creates a figure window with a map axes and activates the Projection Control dialog box for defining map projection and display properties. The figure window features a special menu bar that provides access to most of Mapping Toolbox GUIs.

`maptool(`*`PropertyName`*`,PropertyValue,...)` creates a figure window with a map axes defined by the supplied map properties. The `MapProjection` property must be the first input pair. `maptool` supports the same map properties as `axesm`.

`maptool(`*`ProjectionFile`*`,`*`PropertyName`*`, PropertyValue,...)` allows for the omission of the `MapProjection` property name. *`ProjectionFile`* must be the identifying string of an available map projection.

`h = maptool(...)` returns a two-element vector containing the handle of the `maptool` figure window and the handle of the map axes.

Controls



Session Menu

The **Load** option is used to load workspace data. Select from the workspace names provided, or use the **Specify Workspace** option to enter a different workspace.

The **Layers** option is used to load a map layers workspace and activate the `mlayers` tool. Select from the workspace names provided, or use the **Other** option to enter a different workspace. Choosing **Workspace** loads all structure variables in the current workspace.

The **Renderer** option is used to set the renderer for the maptool figure window. The Figure Renderer dialog box is activated when this option is selected.

The **Variables** option is used to view the current workspace variables.

The **Command** option brings up the Workspace Commands dialog box for entering commands to operate on the current workspace.

The **Clear** option is used to clear variables and functions from memory.

Map Menu

The **Lines** option activates the Line Map Input dialog box for projecting two- and three-dimensional line objects onto the map axes.

The **Patches** option activates the Patch Map Input dialog box for projecting patch objects onto the map axes.

The **Regular Surfaces** option activates the Mesh Map Input dialog box for projecting a regular data grid onto a graticule projected onto the map axes.

The **General Surfaces** option activates the Surface Map Input dialog box for projecting a geolocated data grid onto the map axes.

The **Contours** option activates the Contour Map Input dialog box for projecting a two- or three-dimensional contour plot onto the map axes.

The **Quiver 2D** option activates the Quiver Map Input dialog box for projecting a two-dimensional quiver plot onto the map axes.

The **Quiver 3D** option activates the Quiver3 Map Input dialog box for projecting a three-dimensional quiver plot onto the map axes.

The **Stem** option activates the Stem Map Input dialog box for projecting a stem plot onto the map axes.

The **Scatter** option activates the Scatter Map Input dialog box for projecting a scatter plot onto the map axes.

The **Text** option activates the Text Map Input dialog box for projecting text objects onto the map axes.

The **Light** option activates the Light Map Input dialog box for projecting light objects onto the map axes.

Display Menu

The **Projection** option activates the Projection Control dialog box for editing map projection properties and map display settings.

The **Graticule** option is used to view and edit the graticule size for surface maps.

The **Legend** option is used to display a contour map legend.

The **Frame** option is used to toggle the map frame on and off.

The **Grid** option is used to toggle the map grid on and off.

The **Meridian Labels** option is used to toggle the meridian grid labels on and off.

The **Parallel Labels** option is used to toggle the parallel grid labels on and off.

The **Tracks** option activates the Define Tracks input box for calculating and displaying Great Circle and Rhumb Line tracks on the map axes.

The **Small Circles** option activates the Define Small Circles input box for calculating and displaying small circles on the map axes.

The **Surface Distances** option activates the Surface Distance dialog box for distance, azimuth, and reckoning calculations.

Tools Menu

The **Hide** option is used to hide the mouse tool buttons.

The **Off** option is used to turn off the current mouse tool.

The **Zoom Tool** option is used to toggle Panzoom (`panzoom`) mode on and off. It is used for zooming in on a two-dimensional map display.

The **Set Limits** option is used to define the zoom out limits to the current settings on the axes.

The **Full View** option is used to zoom out to the current axes limit settings.

The **Rotate** option is used to toggle Rotate 3-D (`rotate3d`) mode on and off. Rotate 3-D mode is used to interactively rotate the view of a three-dimensional plot.

The **Origin** option is used to toggle Origin (`originui`) mode on and off. Origin mode is used to interactively modify the map origin.

The **2D View** option is used to set the default two-dimensional view (azimuth=0, elevation=90).

The **Objects** option activates the Object Sets dialog box, which allows for property manipulation of objects displayed on the map axes.

The **Edit** option activates the MATLAB Property Editor to manipulate properties of a plotted object. Choose from the **Current Object** or **Last Object** options, or choose the **Object** option to activate the Select Object dialog box.

The **Show** option is used to set the `Visible` property of mapped objects to `'on'`. The **All** option shows all currently mapped objects. The **Object** option activates the Select Object dialog box.

The **Hide** option is used to set the `Visible` property of mapped objects to `'off'`. Choose from the **All** or **Map** options, or choose the **Object** option to activate the Select Object dialog box.

The **Delete** option is used to clear the selected objects. The **All** option clears the current map, frame, and grid lines. The map definition is left in the axes definition. The **Map** option clears the current map, deleting objects plotted on the map but leaving the frame and grid lines displayed. The **Object** option activates the Select Object dialog box.

The **Axes** option is used to manipulate the MATLAB Cartesian axes. The **Show** option shows this axes, the **Hide** option hides this axes, and the **Color** option allows for custom color selection for this axes.

Colormaps Menu

The **Colormaps** menu allows for manipulation of the colormap for the current figure. See the `clrmenu` reference page for details on the **Colormaps** menu options.

The **Zoom** button toggles Zoom mode on and off. Zoom mode is used for zooming in on a two-dimensional map display.

The **Rotate** button toggles Rotate 3-D mode on and off. Rotate 3-D mode is used to interactively rotate the view of a three-dimensional plot.

The **Origin** button toggles Origin mode on and off. Origin mode is used to interactively modify the map origin.

See Also

`axesm`

Purpose

Interactively trim and convert map data from vector to raster format

Activation

Command Line
`maptrim(lat,lon)`
`maptrim(lat,lon,`*`linespec`*`)`
`maptrim(datagrid,refvec)`
`maptrim(datagrid,refvec,`*`PropertyName`*`,PropertyValue,...)`

Description

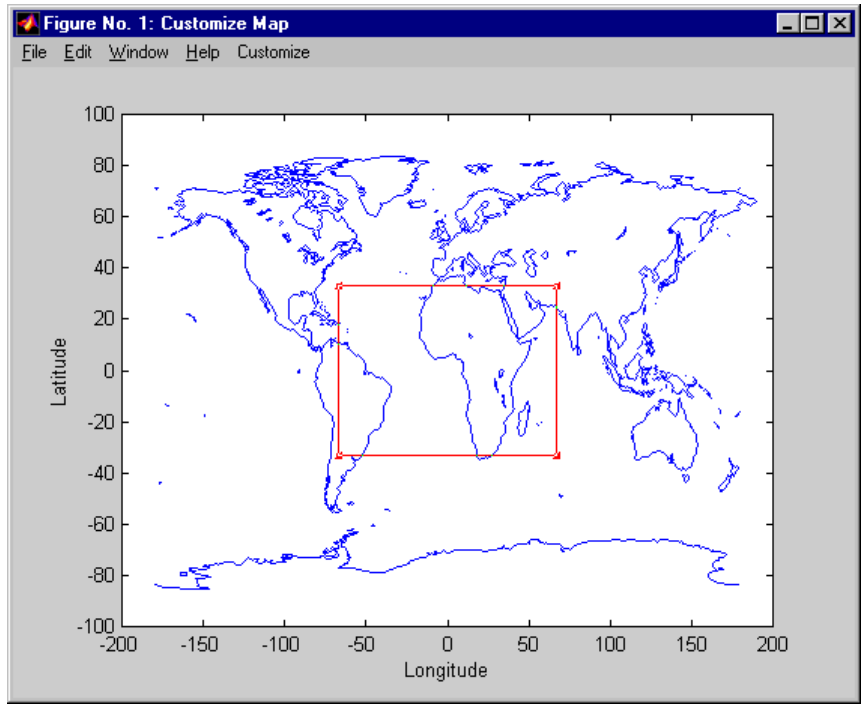
`maptrim(lat,lon)` displays the supplied map data in a new figure window and allows a region of the map to be selected and saved in the workspace. `lat` and `lon` must be vector map data. The output can be line, patch, or regular surface (matrix) data. If patch map output is selected, the inputs `lat` and `lon` must originally be patch map data.

`maptrim(lat,lon,`*`linespec`*`)` displays the supplied map data using the *`linespec`* string.

`maptrim(datagrid,refvec)` displays data grid data in a new figure window and allows a subset of this map to be selected and saved. The output is regular surface data.

`maptrim(datagrid,refvec,`*`PropertyName`*`,PropertyValue)` displays the data grid using the surface properties provided. The object `Tag`, `EdgeColor`, and `UserData` properties cannot be set.

Controls

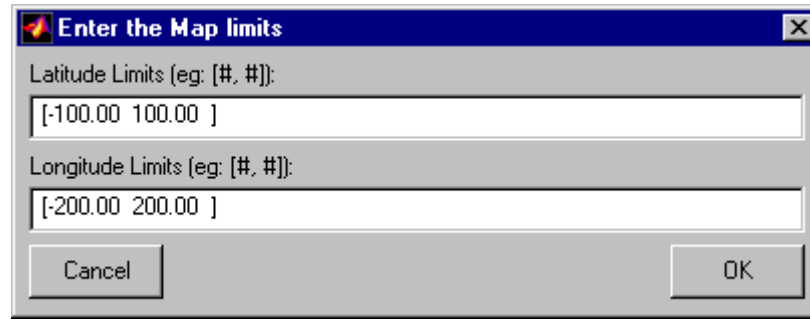


The `maptrim` tool displays the supplied map data in a new figure window and activates a **Customize** menu for that figure. The **Customize** menu has three menu options: **Zoom On/Off**, **Limits**, and **Save As**.

The **Zoom On/Off** menu option toggles the `panzoom` box on and off. The box can be moved by clicking the new location or by dragging the box to the new location. The box size can be increased or decreased by dragging a corner of the box. Pressing the `Return` key or double-clicking in the center of the box zooms in.

The **Limits** menu option activates the Enter Map Limits dialog box, which is used to enter the latitude and longitude limits of the desired map subset. These entries are two-element vectors, enclosed in brackets. Pressing the **OK** button zooms in to the new limits. Pressing

the **Cancel** button disregards the new limits and returns to the map display.



The **Save As** menu option is used to specify the variable names in which to save the map data subset. To save line and patch data, enter the new latitude and longitude variable names, along with the map resolution. For surface data, enter the new map and referencing vector variable names, along with the scale of the map. Latitude and longitude limits are optional.

See Also

`maptriml` | `maptrimp` | `maptrims` | `panzoom`

mlayers

Purpose

GUI to control plotting of display structure elements

Activation

Command Line	Maptool
`mlayers('filename')`	**Session > Layers**
`mlayers('filename',h)`	
`mlayers(cellarray)`	
`mlayers(cellarray,h)`	

Description

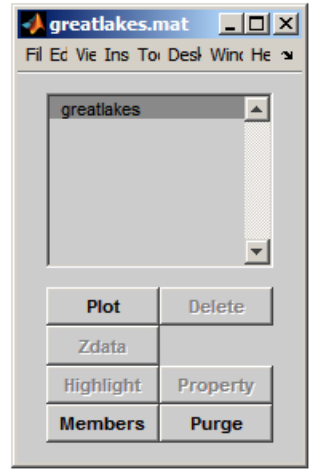
`mlayers('filename')` associates all display structures, which in this context are also called map layers, in the MAT-file `filename` with the current map axes. The display structure variables are accessible only through the `mlayers` tool, and not through the base workspace. `filename` must be a string.

`mlayers('filename',h)` assigns the layers found in `filename` to the map axes indicated by the handle `h`.

`mlayers(cellarray)` associates the layers specified by `cellarray` with the current map axes. `cellarray` must be of size n by 2. Each row of `cellarray` represents a map layer. The first column of `cellarray` contains the layer structure, and the second column contains the name of the layer structure. Such a cell array can be generated from data in the current workspace with the function `rootlayr`. In this case, the calling sequence would be `rootlayr; mlayers(ans)`.

`mlayers(cellarray,h)` assigns the layers specified by `cellarray` to the map axes specified by the handle `h`.

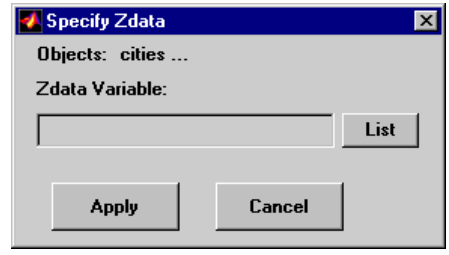
Controls



The scrollable list box displays all of the map layers currently associated with the map axes. An asterisk next to the layer name indicates that the layer is currently visible. An `h` next to the layer name indicates a layer that is plotted, but currently hidden.

The **Plot** button plots the selected map layer. Once the selected layer is plotted, the button toggles between **Hide** and **Show**, to turn the `Visible` property of the plotted objects to `'off'` and `'on'`, respectively.

The **Zdata** button activates the Specify Zdata dialog box, which is used to enter the workspace variable containing the `ZData` for the selected map layer. Pressing the **List** button produces a list of all current workspace variables, from which the `ZData` variable can be selected. This entry can also be a scalar.

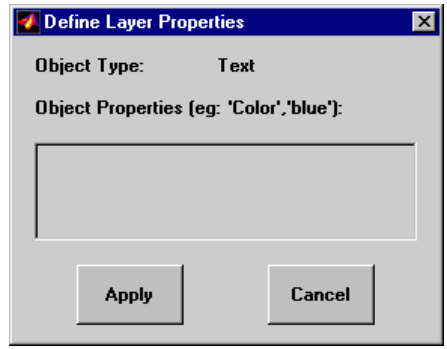


The **Highlight** button is used to toggle the selected map layer between highlighted and normal display.

The **Members** button brings up a list of members of the selected map layer. Members of a layer are defined by their `Tag` property.

The **Delete** button deletes the selected map layer from the map.

The **Property** button activates the Define Layer Properties dialog box, which is used to specify or change properties of all objects in the selected map layer. String entries must be enclosed in single quotes.



The **Purge** button deletes the selected map layer from the `mlayers` tool. Selecting **Yes** from the Confirm Purge dialog box deletes the map layer from both the `mlayers` tool and the map display. Selecting **Data Only** from the Confirm Purge dialog box deletes the map layer from the `mlayers` tool, while retaining the plotted object on the map display.

See Also

`mobjects | rootlayr`

Purpose

Manipulate object sets displayed on map axes

Activation

Command Line	Maptool
`mobjects` `mobjects(h)`	**Tools > Objects**

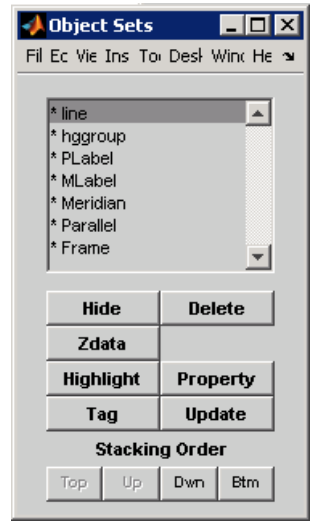
Description

An object set is defined as all objects with identical tags. If no tags are supplied, object sets are defined by object type.

`mobjects` allows manipulation of the object sets on the current map axes.

`mobjects(h)` allows manipulation of the objects set on the map axes specified by the handle `h`.

Controls

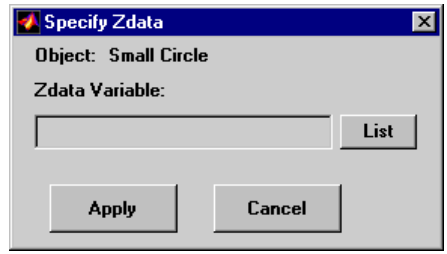


The scrollable list box displays all of the object sets associated with the map axes. An asterisk next to an object set name indicates that the object set is currently visible. An `h` next to an object set name indicates

an object set that is plotted, but currently hidden. The order shown in the list indicates the stacking order of objects within the same plane.

The **Hide/Show** button toggles the `Visible` property of the selected object set to `'off'` and `'on'`, respectively, depending on the current `Visible` status.

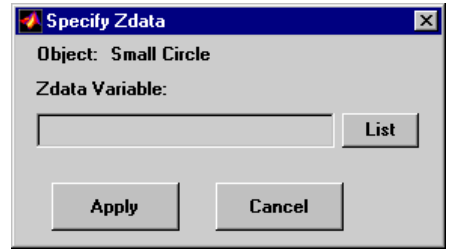
The **Zdata** button activates the Specify Zdata dialog box, which is used to enter the workspace variable containing the `ZData`. The `ZData` property is used to specify the plane in which the selected object set is drawn. Pressing the **List** button produces a list of all current workspace variables, from which the `ZData` variable can be selected. Alternatively, a scalar value can be entered instead of a variable.



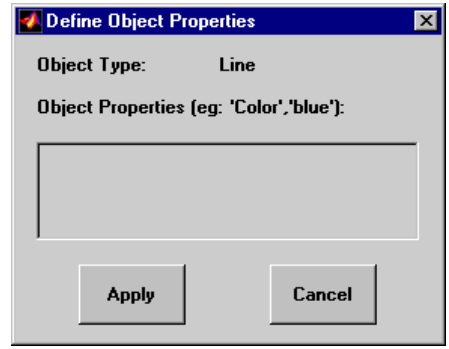
The **Highlight** button highlights all objects belonging to the selected object set.

The **Tag** button brings up an Edit Tag dialog box, which allows the tag of all members of the selected object set to be modified.

The **Delete** button clears all objects belonging to the selected object set from the map. The cleared object set remains associated with the map axes.



The **Property** button activates the Define Object Properties dialog box, which is used to specify additional properties of all objects in the selected object set. String entries must be enclosed in single quotes.



The **Update** button updates the list box display with current objects sets.

The **Stacking Order** buttons are used to modify the drawing order of the selected object set in relation to other plotted object sets in the same plane. Objects drawn first appear at the bottom of the stack, and objects drawn last appear at the top of the stack. The **Top** button places the selected object set above all other object sets in its plane. The **Up** and **Dwn** buttons move the selected object set up and down one place in the stacking order, respectively. The **Btm** button places the selected object set below all other object sets in its plane. Note that the `ZData` property overrides stacking order, i.e., if an object is at the top of the stacking order for its plane, it can still be covered by an object drawn in a higher plane.

See Also `mlayers`

Purpose

Interactively modify map origin

Activation

Command Line	Maptool

`originui`
`originui on`
`originui off`
	Tools > Origin
	(menu) > Origin(button)

Description

`originui` provides a tool to modify the origin of a displayed map projection. A marker (dot) is displayed where the origin is currently located. This dot can be moved and the map reprojected with the identified point as the new origin.

`originui` automatically toggles the current axes into a mode where only actions recognized by `originui` are executed. Upon exit of this mode, all prior `ButtonDown` functions are restored to the current axes and its children.

`originui on` activates origin tool. `originui off` e-activates the tool. `originui` will toggle between these two states.

Controls

Keystrokes

`originui` recognizes the following keystrokes. **Enter** (or **Return**) will reproject the map with the identified origin and remain in the `originui` mode. **Delete** and **Escape** will exit the origin mode (same as `originui off`). **N**,**S**,**E**,**W** keys move the marker North, South, East or West by 10.0 degrees for each keystroke. **n**,**s**,**e**,**w** keys move the marker in the respective directions by 1 degree per keystroke.

Mouse Actions

`originui` recognizes the following mouse actions when the cursor is on the origin marker.

- Single-click and hold moves the origin marker. Double-click the marker reprojects the map with the specified map origin and remains in the origin mode (same as `originui` **Return**).
- Extended-click moves the marker along the Cartesian X or Y direction only (depending on the direction of greatest movement).
- Alternate-click exits the origin tool (same as `originui off`).

Macintosh Key Mapping

- Extend-click: **Shift**+click mouse button
- Alternate-click: **Option**+click mouse button

Microsoft Windows Key Mapping

- Extend-click: **Shift**+click left button or both buttons
- Alternate-click: **Ctrl**+click left button or right button

X-Windows Key Mapping

- Extend-click: **Shift**+click left button or middle button
- Alternate-click: **Ctrl**+click left button or right button

See Also

`axesm | setm`

Purpose

Pan and zoom on map axes

Activation

Command Line	Maptool

`panzoom`
`panzoom on`
`panzoom off`
`panzoom setlimits`
`panzoom out`
`panzoom fullview`
	Tools > Zoom Tool
	(menu) > Zoom (button)

Description

`panzoom` toggles the pan and zoom tool on and off.

`panzoom on` activates the pan and zoom tool.

`panzoom off` deactivates the pan and zoom tool.

`panzoom setlimits` sets the zoom out limits to the current settings on the map axes.

`panzoom out` zooms out to the current map axes limit settings.

`panzoom fullview` resets the axes to their full view range and resets the pan and zoom tool with these settings.

The pan and zoom tool provides an interactive means of defining zoom limits on a two-dimensional map display. A box that can be resized and moved appears on the map display and is used to define the zoom area. The box cannot be moved beyond the current axes limits.

Controls

Mouse Interaction

With the cursor inside the zoom box, a single-click and drag moves the box. The zoom box can be resized by dragging the corners of the box. A double-click in the center of the box zooms in to the current boundaries of the box. A single-click outside the zoom box moves the box to that

location. An extend-click inside or outside of the zoom box zooms out by a factor of two. Alternate-click exits the pan and zoom tool.

Keyboard Interaction

The following keyboard interaction is enabled if the figure containing the map axes is made the active window.

Pressing the **Return** key sets the axes to the current zoom box and remains in pan and zoom mode. The **Enter** key sets the axes to the current zoom box and exits pan and zoom mode. Pressing the **Esc** or **Delete** keys exits pan and zoom mode.

See Also

`zoom`

Purpose

Interactively modify map parallels

Activation

Command Line	Maptool
`parallelui`	**Tools > Parallels (menu)**
`parallelui on`	
`parallelui off`	

Description

`parallelui` toggles the parallel tool on and off.

`parallelui on` activates the parallel tool

`parallelui off` deactivates the parallel tool

The `parallelui` GUI provides a tool to modify the standard parallels of a displayed map projection. One or two red lines are displayed where the standard parallels are currently located. The parallel lines can be dragged to new locations, and the map reprojected with the locations of the parallel lines as the new standard parallels.

Controls

Mouse Interaction

A single-click-and-drag moves the parallel lines. A double-click on one of the standard parallels reprojects the map using the new parallel locations.

See Also

`axesm | setm`

property editors

Purpose

GUIs to edit properties of mapped objects

Activation

map display:	Alternate-click mapped object (for Click-and-Drag Property Editor)
	In plot edit mode, double-click mapped object (to obtain MATLAB Property Editor; click the **More Properties...** button to open the Property Inspector)
maptool:	**Tools > Edit Plot** menu item (for MATLAB Property Editor)

Description

Alternate (e.g., **Ctrl**+clicking a mapped object activates a property editor, which allows modification of some basic properties of the object through simple mouse clicks and drags. The objects supported by this editor are map axes, lines, text, patches, and surfaces, and the properties supported for each object type are shown below.

In plot edit mode, double-clicking a mapped object activates the MATLAB Property Editor for that object. From the Property Editor you can launch the Property Inspector, a GUI that lists the properties and values of the selected object and allows you to modify them.

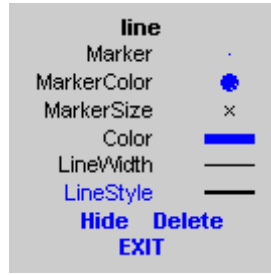
Controls

Click-and-Drag Property Editor

The Click-and-Drag editor lists object properties and values. The object tag appears at the top of the editor. Property names and values that appear in blue are toggles. For example, clicking **Frame** in the axes editor toggles the value of the `Frame` property between `'on'` and `'off'`.

Click-and-Drag Editor for a map axes

Property values that appear on the right side of the editor box are modified by clicking and dragging. For example, to change the `MarkerColor` property of a line object, click and hold the dot next to **MarkerColor**, and drag the cursor until the dot appears in the desired color.



Click-and-Drag Editor for a line object

The **Drag** control in the text editor is used to reposition the text string. In drag mode, use the mouse to move the text to a new location, and click to reposition the text. The **Edit** control in the text editor activates a **Text Edit** window, which is used to modify text.

Click-and-Drag Editor for a text object

The **Marker** property name in the patch editor is used to toggle the marker on and off. The property value to the right of **Marker** can be modified by clicking and dragging until the desired marker symbol appears.

Click-and-Drag Editor for a patch object

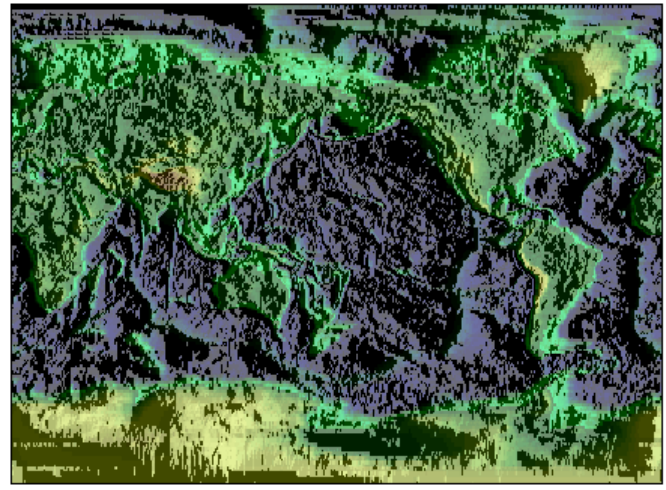
The **Graticule** control on the surface editor activates a Graticule Mesh dialog box, which is used to alter the size of the graticule.

To move the property editor around the figure window, hold down the **Shift** key while dragging the editor box. Alternate-clicking the background of the property editor closes the **Click-and-Drag** editing session.

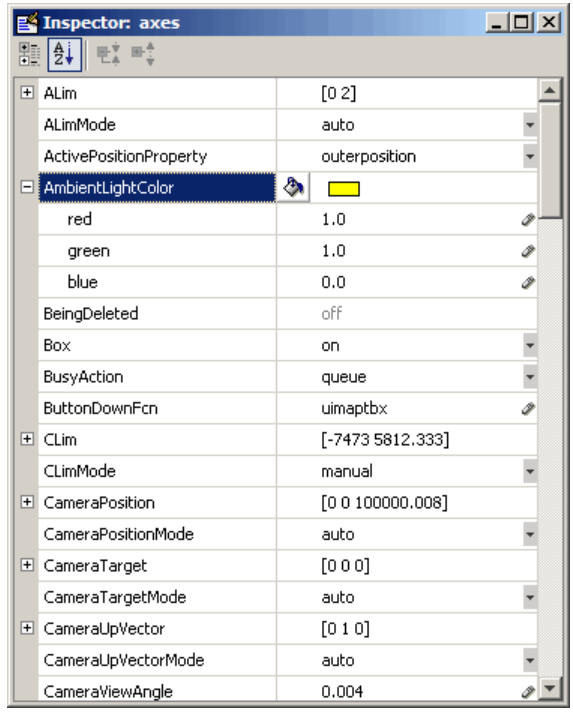
Guide Property Editor

The MATLAB Property Inspector (the `inspect` function) allows you to view and modify property values for most properties of the selected

object. Use it to expand and collapse the hierarchy of objects, showing an object's parents and children. A plus sign (+) before a property indicates that it can be expanded to show its components, for example the axes `AmbientLightColor` applied to the surface object displayed below. A minus sign (-) before an object indicates an object can be collapsed to hide its components. To activate the Object Browser, check the **Show Object Browser** check box. The **Property List** shows all the property names of the selected object and their current values. To activate the **Property List**, check the **Show Property List** check box. To change a property value, use the edit boxes above the Property List. Pressing the **Close** button closes the Guide Property Editor and applies the property modifications to the object.



A lit surface object in a map axes



Property Inspector view of axes object

See Also

`propedit` | `inspect` | `uimaptbx`

Purpose

GUI to interactively perform data queries

Activation

Command Line
`qrydata(cellarray)`
`qrydata(titlestr,cellarray)`
`qrydata(h,cellarray)`
`qrydata(h,titlestr,cellarray)`
`qrydata(...,cellarray1,cellarray2,...)`

Description

A data query is used to obtain the data corresponding to a particular (x,y) or (lat,lon) point on a standard or map axes.

`qrydata(cellarray)` activates a data query dialog box for interactive queries of the data set specified by `cellarray` (described below). `qrydata` can be used on a standard axes or a map axes. `(x,y)` or `(lat,lon)` coordinates are entered in the dialog box, and the data corresponding to these coordinates is then displayed.

`qrydata(titlestr,cellarray)` uses the string *`titlestr`* as the title of the query dialog box.

`qrydata(h,cellarray)` and `qrydata(h,titlestr,cellarray)` associate the data queries with the axes specified by the handle `h`, which in turn allows the input coordinates to be specified by clicking the axes.

The input `cellarray` is used to define the data set and the query. The first cell must contain the string used to label the data display line. The second cell must contain the type of query operation, either a predefined operation or a valid user-defined function name. This input must be a string. The predefined query operations are `'matrix'`, `'vector'`, `'mapmatrix'`, and `'mapvector'`.

The `'matrix'` query uses the MATLAB `interp2` function to find the value of the matrix `Z` at the input `(x,y)` point. The format of the `cellarray` input for this query is:

`{'label','matrix',X,Y,Z,`*`method`*`}`. `X` and `Y` are matrices specifying the points at which the data `Z` is given. The rows and columns of `X` and `Y` must be monotonic. *`method`* is an optional argument that specifies the interpolation method. Possible *`method`* strings are `'nearest'`, `'linear'`, or `'cubic'`. The default is `'nearest'`.

The `'vector'` query uses the `interp2` function to find the value of the matrix `Z` at the input `(x,y)` point, then uses that value as an index to a data vector. The value of the data vector at that index is returned by the query. The format of `cellarray` for this type of query is: `{'label','vector',X,Y,Z, vector}`. `X` and `Y` are matrices specifying the points at which the data `Z` is given. The rows and columns of `X` and `Y` must be monotonic. `vector` is the data vector.

The `'mapmatrix'` query interpolates to find the value of the map at the input `(lat,lon)` point. The format of `cellarray` for this query is: `{'label','mapmatrix',datagrid,refvec,`*`method`*`}`. `datagrid` and `refvec` are the data grid and the corresponding referencing vector. *`method`* is an optional argument that specifies the interpolation method. Possible *`method`* strings are `'nearest'`, `'linear'`, or `'cubic'`. The default is `'nearest'`.

The `'mapvector'` query interpolates to find the value of the map at the input `(lat,lon)` point, then uses that value as an index to a data vector. The value of the vector at that index is returned by the query. The format of `cellarray` for this type of query is `{'label','mapvector',datagrid,refvec, vector}`. `datagrid` and `refvec` are the data grid and the corresponding referencing vector. `vector` is the data vector.

User-defined query operations allow for functional operations using the input `(x,y)` or `(lat,lon)` coordinates. The format of `cellarray` for this type of query is `{'label',`*`function`*`,other arguments...}` where the other arguments are the remaining elements of `cellarray` as in the four predefined operations above. *`function`* is a user-created function and must refer to a MATLAB function with the signature `z = fcn(x,y,other_arguments...)`.

`qrydata(...,cellarray1,cellarray2,...)` is used to input multiple cell arrays. This allows more than one data query to be performed on a given point.

Controls

Sample data query dialog box

If an axes handle `h` is not provided, or if the axes specified by `h` is not a map axes, the currently selected point is labeled as **Xloc** and **Yloc** at the top of the query dialog box. If `h` is a map axes, the current point is labeled as **Lat** and **Lon**. Displayed below the current point are the results from the queries, each labeled as specified by the `'label'` input arguments.

The **Get** button appears if an axes handle `h` is provided. Pressing this button activates a mouse cursor, which is used to select the desired point by clicking the axes. Once a point is selected, the queries are performed and the results are displayed.

The **Process** button appears if the handle `h` is not provided. In this case, the `(x,y)` coordinates of the desired point are entered into the edit boxes. Pressing the **Process** button performs the data queries and displays the results.

Pressing the **Close** button closes the query dialog box.

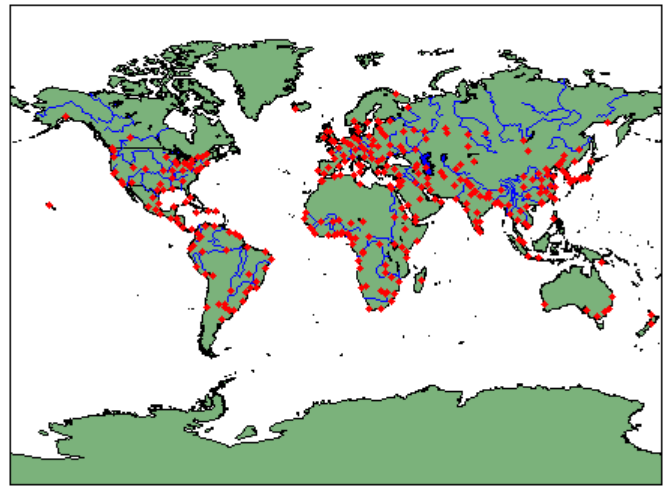
Examples

This example illustrates use of a user-defined query to display city names for map points specified by a mouse click. The query is evaluated by a user-supplied file called `qrytest.m`, described below:

```
axesm miller
land = shaperead('landareas', 'UseGeoCoords', true);
geoshow(land, 'FaceColor', [0.5 0.7 0.5])
lakes = shaperead('worldlakes', 'UseGeoCoords', true);
geoshow(lakes, 'FaceColor', 'blue')
rivers = shaperead('worldrivers', 'UseGeoCoords', true);
geoshow(rivers, 'Color', 'blue')
cities = shaperead('worldcities', 'UseGeoCoords', true);
geoshow(cities, 'Marker', '.', 'Color', 'red')
tightmap
lat = [cities.Lat]';
lon = [cities.Lon]';
mat = char(cities.Name);
qrydata(gca,'City Data',{'City','qrytest',lat,lon,mat})
```

Create the file `qrytest.m` on your path, and in it put the following code:

```
function cityname = qrytest(lt, lg, lat, lon, mat)
% function QRYTEST returns city name for mouse click
% QRYTEST will find the closest city (min radius) from
% the mouse click, within an angle of 5 degrees.
%
latdiff = lt-lat;
londiff = lg-lon;
rad = sqrt(latdiff.^2+londiff.^2);
[minrad,index] = min(rad);
if minrad > 5
  index = [];
end
switch length(index)
  case 0, cityname = 'No city located near click';
  case 1, cityname = mat(index,:);
end
```



Clicking the mouse over a city marker displays the name of the selected city. Clicking the mouse in an area away from any city markers displays the string `'No city located near click'`.

See Also

`interp2`

scirclui

Purpose

GUI to display small circles on map axes

Note `scirclui` is obsolete. Use `scircleg` instead.

Activation

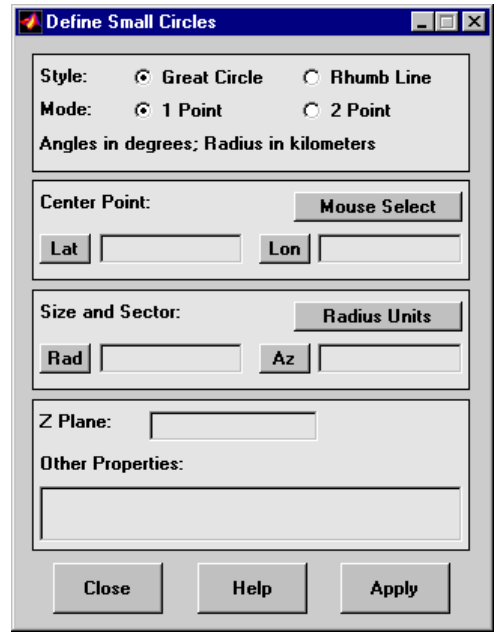
Command Line	Maptool
`scirclui` `scirclui(h)`	**Display mall Circles**

Description

`scirclui` activates the Define Small Circles dialog box for adding small circles to the current map axes.

`scirclui(h)` activates the Define Small Circles dialog box for adding small circles to the map axes specified by the axes handle `h`.

Controls



Define Small Circles dialog box for one-point mode

The **Style** selection buttons are used to specify whether the circle radius is a constant great circle distance or a constant rhumb line distance.

The **Mode** selection buttons are used to specify whether one point or two points are to be used in defining the small circle. If one-point mode is selected, a center point, radius, and azimuth are the required inputs. If two-point mode is selected, a center point, and perimeter point on the circle are the required inputs.

The **Center Point** controls are used in both one-point and two-point mode. The **Lat** and **Lon** edit boxes are used to enter the latitude and longitude of the center point of the small circle to be displayed. These values must be in degrees. To display more than one small circle, a vector of values can be entered, enclosed in brackets in each edit box. Pushing the **Lat** or **Lon** button brings up an expanded edit box for easier entry of long vectors. The **Mouse Select** button is used to select

a center point by clicking the displayed map. The coordinates of the selected point then appear in the **Lat** and **Lon** edit boxes and can be modified. The coordinates appear in degrees, regardless of the angle units defined for the current map projection.

The **Circle Point** controls are used only in two-point mode. The **Lat** and **Lon** edit boxes are used to enter the latitude and longitude of a point on the perimeter of the small circle to be displayed. These values must be in degrees. To display more than one small circle, a vector of values can be entered, enclosed in brackets in each edit box. Pushing the **Lat** or **Lon** button brings up an expanded edit box for easier entry of long vectors. The **Mouse Select** button is used to select a perimeter point by clicking the displayed map. The coordinates of the selected point then appear in the **Lat** and **Lon** edit boxes and can be modified. The coordinates appear in degrees, regardless of the angle units defined for the current map projection.

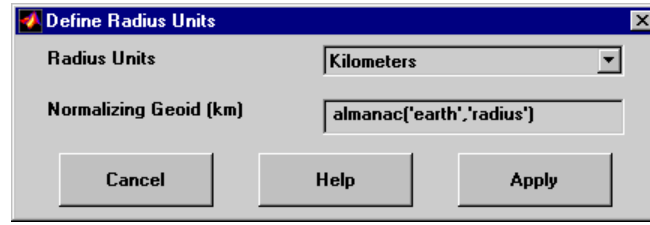
The **Size and Sector** controls are used only in one-point mode. The **Radius Units** button brings up a Define Radius Units dialog box, which allows for modification of the small circle radius units and the normalizing geoid. The **Rad** edit box is used to enter the radius of the small circle in the proper units. The **Arc** edit box is used to specify the sector azimuth, measured in degrees, clockwise from due north. If the entry is omitted, a complete small circle is drawn. When entering radius and arc data for more than one small circle, vectors of values, enclosed in brackets, are entered in each edit box. Pushing the **Rad** or **Arc** button brings up an expanded edit box for that entry, which is useful for entering long vectors.

The **Z Plane** edit box is used to enter a scalar value that specifies the plane in which to display the small circles.

The **Other Properties** edit box is used to specify additional properties of the small circles to be projected, such as `'Color','b'`. String entries must be enclosed in quotes.

Pressing the **Apply** button accepts the input data and displays the small circles on the current map axes.

Pressing the **Cancel** button disregards any input data and closes the Define Small Circles dialog box.



Define Radius Units Dialog Box

This dialog box, available only in one-point mode, allows for modification of the small circle radius units and the normalizing geoid.

The **Radius Units** pull-down menu is used to select the units of the small circle radius. The unit selected is displayed near the top of the Define Small Circles dialog box, and all latitude and longitude entries must be entered in these units. Users must also be sure to specify the normalizing geoid in the same units. If radians are selected, it is assumed the radius entry is a multiple of the radius used to display the current map, as defined by the map geoid property.

The **Normalizing Geoid** edit box is used modify the radius used to normalize the small circle radius to a radian value, which is necessary for proper calculations and map display. This entry must be in the same units as the small circle radius. If the small circle radius units are in radians, then the normalizing geoid must be the same as the geoid used for the current map axes.

Pressing the **Cancel** button disregards any modifications and closes the Define Radius Units dialog box.

Pressing the **Apply** button accepts any modifications and returns to the Define Small Circles dialog box.

See Also

`scircle1` | `scircle2`

seedm

Purpose

GUI to fill data grids with seeded values

Activation

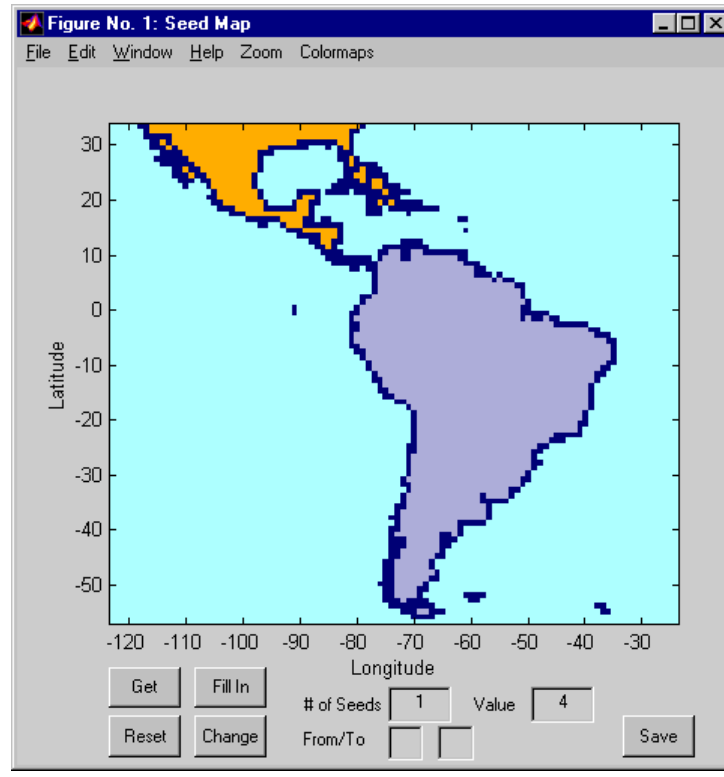
Command Line
`seedm(datagrid,refvec)`

Description

Encoding is the process of filling in specific values in regions of a data grid up to specified boundaries, which are indicated by entries of 1 in the variable `map`. Encoding entire regions at one time allows indexed maps to be created quickly.

`seedm(datagrid,refvec)` displays the surface map in a new figure window and allows for seeds to be specified and the encoded map generated. The encoded map can then be saved to the workspace. `map` is the data grid and must consist of positive integer index values. `refvec` is the referencing vector of the surface.

Controls



The **Zoom On/Off** menu toggles the zoom box on and off. The box can be moved by clicking the new location or by dragging the box to the new location. The box size can be increased or decreased by dragging a corner of the box. Pressing the **Return** key or double-clicking in the center of the box zooms in to the box limits.

The **Colormaps** menu provides a variety of colormap options that can be applied to the map. See `clrmenu` in this guide for a description of the **Colormaps** menu options.

The **Get** button allows mouse selection of points on the map to which seeds are assigned. The number of points to be selected is entered in the **# of Seeds** edit box. The value of the seed is entered in the **Value**

edit box. This seed value is assigned to each point selected with the mouse. The **Get** button is pressed to begin mouse selection. After all the points have been selected, the **Fill In** button is pressed to perform the encoding operation. The region containing the seed point is filled in with the seed value. The **Reset** button is used to disregard all points selected with the mouse before the **Fill In** button is pressed.

Alternatively, specific map values can be globally replaced by using the **From/To** edit boxes. The value to be replaced is entered in the first edit box, and the new value is entered in the second edit box. Pressing the **Change** button replaces all instances of the **From** value to the **To** value in the map.

Note Values of 1 represent boundaries and should not be changed.

The **Save** button is used to save the encoded map to the workspace. A dialog box appears in which the map variable name is entered.

See Also

`colorm` | `encodem` | `getseeds` | `maptrim`

Purpose

Show specified mapped objects

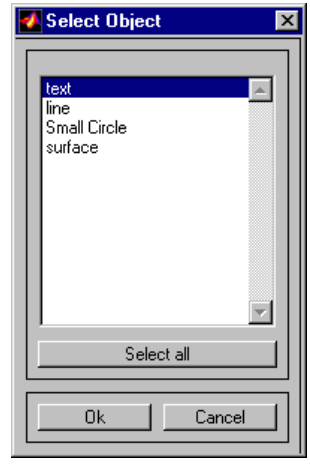
Activation

Command Line	Maptool
`showm`	**Tools > Show > Object**

Description

`showm` brings up a Select Object dialog box for selecting mapped objects to show (`Visible` property set to `'on'`).

Controls



The scroll box is used to select the desired objects from the list of mapped objects. Pushing the **Select all** button highlights all objects in the scroll box for selection. Pushing the **OK** button changes the `Visible` property of the selected objects to `'on'`. Pushing the **Cancel** button aborts the operation without changing any properties of the selected objects.

See Also

`showm`

surfdist

Purpose

Interactive distance, azimuth, and reckoning calculations

Activation

Command Line	Maptool

`surfdist`
`surfdist(h)`
`surfdist([])`
	Display > Surface > Distances

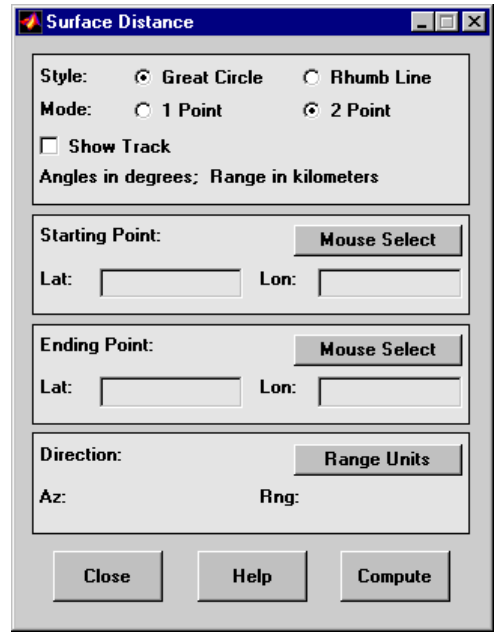
Description

`surfdist` activates the Surface Distance dialog box for the current axes only if the axes has a proper map definition. Otherwise, the Surface Distance dialog box is activated, but is not associated with any axes.

`surfdist(h)` activates the Surface Distance dialog box for the axes specified by the handle `h`. The axes must be a map axes.

`surfdist([])` activates the Surface Distance dialog box and does not associate it with any axes, regardless of whether the current axes has a valid map definition.

Controls



The **Style** selection buttons are used to specify whether a great circle or rhumb line is used to calculate the surface distance. When all other entries are provided, selecting a style updates the surface distance calculation.

The **Mode** selection buttons are used to specify whether one point or two points are to be used in defining the track distance. If one-point mode is selected, a starting point, azimuth, and range are the required inputs, and the ending point is computed. If two-point mode is selected, starting and ending points of the track are required, and the azimuth and distance along this track are then computed.

The **Show Track** check box is used to indicate whether the track is shown on the associated map display. The track is deleted when the Surface Distance dialog box is closed, or when the **Show Track** check box is unchecked and the surface distance calculations are recomputed.

The **Starting Point** controls are used for both one-point and two-point mode. The **Lat** and **Lon** edit boxes are used to enter the latitude and longitude of the starting point of the track. These values must be in degrees. Only one starting point can be entered. The **Mouse Select** button is used to select a starting point by clicking the displayed map. The coordinates of the selected point then appear in the **Lat** and **Lon** edit boxes and can be modified. The coordinates appear in degrees, regardless of the angle units defined for the current map projection.

The **Ending Point** controls are enabled only for two-point mode. The **Lat** and **Lon** edit boxes are used to enter the latitude and longitude of the ending point of the track. These values must be in degrees. Only one ending point can be entered. The **Mouse Select** button is used to select an ending point by clicking the displayed map. The coordinates of the selected point then appear in the **Lat** and **Lon** edit boxes and can be modified. The coordinates appear in degrees, regardless of the angle units defined for the current map projection. During one-point mode, the Ending Point controls are disabled, but the ending point that results from the surface distance calculation is displayed.

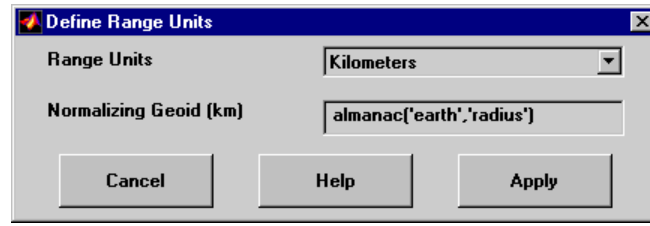
The **Direction** controls are enabled only for one-point mode. The **Range Units** button brings up a Define Range Units dialog box which allows for modification of the range units and the normalizing geoid. The **Az** edit box is used to enter the azimuth, which sets the initial direction of the track from the starting point. Azimuth is measured in degrees clockwise from due north. The **Rng** edit box is used to specify the reckoning range of the track, in the proper units. The azimuth and reckoning range, along with the starting point, are used to compute the ending point of the track in one-point mode. During two-point mode, the **Direction** controls are disabled, but the azimuth and range values resulting from the surface distance calculation are displayed.

Pressing the **Close** button disregards any input data, deletes any surface distance tracks that have been plotted, and closes the Surface Distance dialog box.

Pressing the **Compute** button accepts the input data and computes the specified distances.

Define Range Units Dialog Box

This dialog box, available only for one-point mode, allows for modification of the range units and the normalizing geoid.



The **Range Units** pull-down menu is used to select the units of the reckoning range. The unit selected is displayed near the top of the Surface Distance dialog box, and all latitude and longitude entries must be entered in these units. Users must also be sure to specify the normalizing geoid in the same units. If radians are selected, it is assumed the range entry is a multiple of the radius of the normalizing geoid. In this case, the normalizing geoid must be the same as the geoid used to display the current map.

The **Normalizing Geoid** edit box is used modify the radius used to normalize range entries to radian values, which is necessary for proper calculations and map display. This entry must be in the same units as the range units. If the range units are in radians, then the normalizing geoid must be the same as the geoid used for the current map axes.

Pressing the **Cancel** button disregards any modifications and closes the Define Range Units dialog box.

Pressing the **Apply** button accepts any modifications and returns to the Surface Distance dialog box.

Purpose

GUI to edit tag property of mapped object

Activation

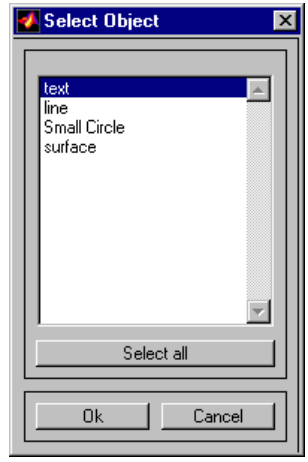
Command Line
`tagm`
`tagm(h)`

Description

`tagm` brings up a Select Object dialog box for selecting mapped objects and changing their `Tag` property. Upon selecting the objects, the Edit Tag dialog box is activated, in which the new tag is entered.

`tagm(h)` activates the Edit Tag dialog box for the objects specified by the handle `h`.

Controls



Select Object Dialog Box

The scroll box is used to select the desired objects from the list of mapped objects. Pushing the **Select all** button highlights all objects in the scroll box for selection. Pushing the Ok button activates the Edit Tag dialog box. Pushing the **Canel** button aborts the operation without changing any properties of the selected objects.

Edit Tag Dialog Box

The new tag string is entered in the edit box. Pressing the **Apply** button changes the `Tag` property of all selected objected to the new tag string. Pressing the **Cancel** button closes the Edit Tag dialog box without changing the `Tag` property of the selected objects.

See Also

`tagm`

trackui

Purpose

GUI to display great circles and rhumb lines on map axes

Note `trackui` is obsolete. Use `trackg` instead.

Activation

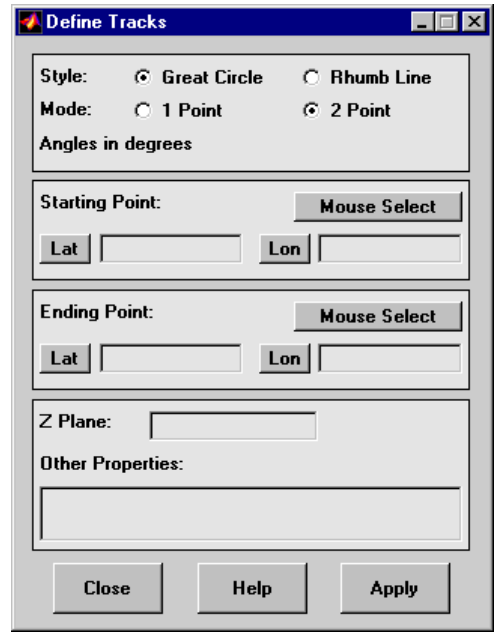
Command Line	Maptool
`trackui` `trackui(h)`	**Display > Tracks**

Description

`trackui` activates the Define Tracks dialog box for adding great circle or rhumb line tracks to the current map axes.

`trackui(h)` activates the Define Tracks dialog box for adding great circle or rhumb line tracks to the map axes specified by the axes handle `h`.

Controls



Define Tracks dialog box for two-point mode

The **Style** selection buttons are used to specify whether a great circle or rhumb line track is displayed.

The **Mode** selection buttons are used to specify whether one point or two points are to be used in defining the track. If one-point mode is selected, a starting point, azimuth, and range are the required inputs. If two-point mode is selected, starting and ending points are required.

The **Starting Point** controls are used for both one-point and two-point mode. The **Lat** and **Lon** edit boxes are used to enter the latitude and longitude of the starting point of the track to be displayed. These values must be in degrees. To display more than one track, a vector of values can be entered, enclosed in brackets in each edit box. Pushing the **Lat** or **Lon** button brings up an expanded edit box for easier entry of long vectors. The **Mouse Select** button is used to select a starting point by clicking the displayed map. The coordinates of the selected point

then appear in the **Lat** and **Lon** edit boxes and can be modified. The coordinates appear in degrees, regardless of the angle units defined for the current map projection.

The **Ending Point** controls are used only for two-point mode. The **Lat** and **Lon** edit boxes are used to enter the latitude and longitude of the ending point of the track to be displayed. These values must be in degrees. To display more than one track, a vector of values can be entered, enclosed in brackets, in each edit box. Pushing the **Lat** or **Lon** button brings up an expanded edit box for easier entry of long vectors. The **Mouse Select** button is used to select an ending point by clicking the displayed map. The coordinates of the selected point then appear in the **Lat** and **Lon** edit boxes and can be modified. The coordinates appear in degrees, regardless of the angle units defined for the current map projection.

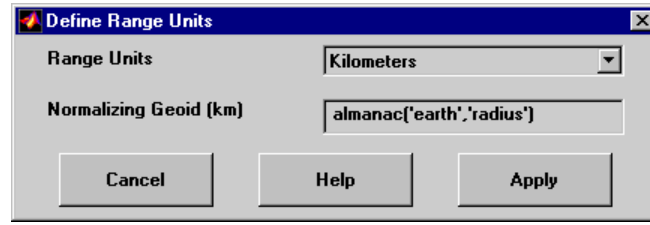
The **Direction** controls are used only for one-point mode. The **Range Units** button brings up a Define Range Units dialog box, which allows for modification of the range units and the normalizing geoid. The **Az** edit box is used to enter the azimuth, which sets the initial direction of the track from the starting point. Azimuth is measured in degrees clockwise from due north. The **Rng** edit box is used to specify the range of the track, in the proper units. If the range entry is omitted, a complete track is drawn. When inputting azimuth and range data for more than one track, vectors of values, enclosed in brackets, are entered in each edit box. Pushing the **Az** or **Rng** button brings up an expanded edit box for that entry, which is useful for entering long vectors.

The **Z Plane** edit box is used to enter a scalar value that specifies the plane in which to display the tracks.

The **Other Properties** edit box is used to specify additional properties of the tracks to be projected, such as `'Color','b'`. String entries must be enclosed in quotes.

Pressing the **Apply** button accepts the input data and displays the tracks on the current map axes.

Pressing the **Cancel** button disregards any input data and closes the Define Tracks dialog box.



Define Range Units Dialog Box

This dialog box, available only for one-point mode, allows for modification of the range units and the normalizing geoid.

The **Range Units** pull-down menu is used to select the units of the track range. The unit selected is displayed near the top of the Define Tracks dialog box, and all latitude and longitude entries must be entered in these units. Users must also be sure to specify the normalizing geoid in the same units. If radians are selected, it is assumed the range entry is a multiple of the radius used to display the current map.

The **Normalizing Geoid** edit box is used to modify the radius used to normalize range entries to radian values, which is necessary for proper calculations and map display. This entry must be in the same units as the range units. If the range units are in radians, then the normalizing geoid must be the same as the geoid used for the current map axes.

Pressing the **Cancel** button disregards any modifications and closes the Define Range Units dialog box.

Pressing the **Apply** button accepts any modifications and returns to the Define Tracks dialog box.

See Also

`track1 | track2`

uimaptbx

Purpose

Handle buttondown callbacks for mapped objects

Activation

set the `ButtonDownFcn` property to `'uimaptbx'`

Description

`uimaptbx` processes mouse events for mapped objects. `uimaptbx` can be assigned to an object by setting the `ButtonDownFcn` to `'uimaptbx'`. This is the default setting for all objects created with Mapping Toolbox functions.

If `uimaptbx` is assigned to an object, the following mouse events are recognized: A single-click and hold on an object displays the object tag. If no tag is assigned, the object type is displayed. A double-click on an object activates the MATLAB Property Editor. An extend-click on an object activates the Projection Control dialog box, which allows the map projection and display properties to be edited. An alternate-click on an object allows basic properties to be edited using simple mouse clicks and drags.

Definitions of extend-click and alternate-click on various platforms are as follows:

`For MS-Windows:`	Extend-click – **Shift**+click left button or both buttons
	Alternate-click – **Ctrl**+click left button or right button
`For X-Windows:`	Extend-click – **Shift**+click left button or middle button
	Alternate-click – **Ctrl**+ click left button or right button

See Also

`axesm | axesmui | property editors`

Purpose

Choose or identify UTM zone by clicking map

Activation

Command Line
`utmzoneui`
`utmzoneui(InitZone)`

Description

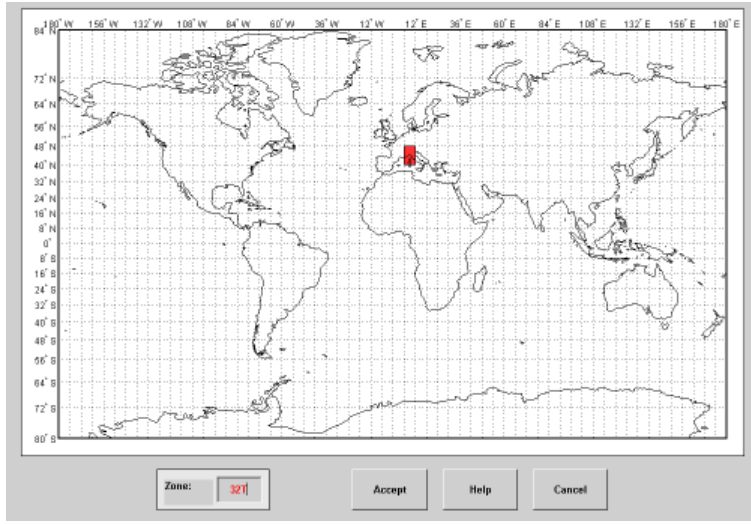
`zone = utmzoneui` will create an interface for choosing a UTM zone on a world display map. It allows for clicking an area for its appropriate zone, or entering a valid zone to identify the zone on the map.

`zone = utmzoneui(InitZone)` will initialize the displayed zone to the zone string given in `InitZone`.

To interactively pick a UTM zone, activate the interface, and then click any rectangular zone on the world map to display its UTM zone. The selected zone is highlighted in red and its designation is displayed in the **Zone** edit field. Alternatively, type a valid UTM designation in the **Zone** edit field to select and see the location of a zone. Valid zone designations consist of an integer from 1 to 60 followed by a letter from C to X.

Typing only the numeric portion of a zone designation will highlight a column of cells. Clicking **Accept** returns a that UTM column designation. You cannot return a letter (row designation) in such a manner, however.

Controls



Tips

The syntax of `utmzoneui` is similar to that of `utmzone`. If `utmzone` is called with no arguments, the `utmzoneui` interface is displayed for you to select a zone. Note that `utmzone` can return latitude-longitude coordinates of a specified zone, but that `utmzoneui` only returns zone names.

See Also

`ups` | `utm` | `utm` | `utmgeoid` | `utmzone`

Purpose

UI for selecting data from Vector Map Level 0

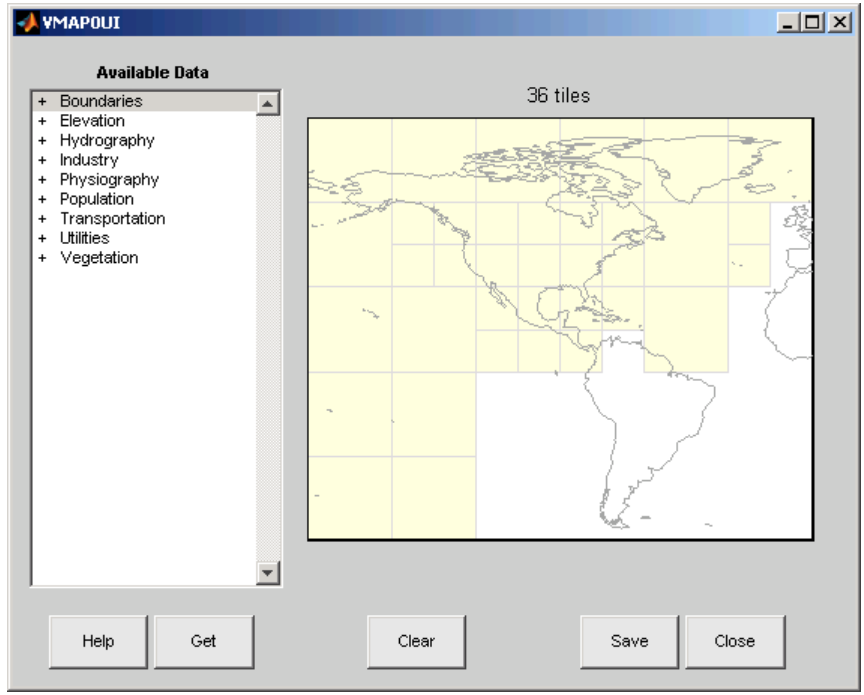
Description

`vmap0ui(dirname)` launches a graphical user interface for interactively selecting and importing data from a Vector Map Level 0 (VMAP0) data base. Use the string `dirname` to specify the folder containing the data base. For more on using `vmap0ui`, click the **Help** button after the interface appears.

`vmap0ui(devicename)` or `vmap0ui devicename` uses the logical device (volume) name specified in string `devicename` to locate CD-ROM drive containing the VMAP0 CD-ROM. Under the Windows operating system it could be `'F:'`, `'G:'`, or some other letter. Under Macintosh OS X it should be `'/Volumes/VMAP'`. Under other UNIX systems it could be `'/cdrom/'`.

`vmap0ui` can be used on Windows without any arguments. In this case it attempts to automatically detect a drive containing a VMAP0 CD-ROM. If `vmap0ui` fails to locate the CD-ROM device, then specify it explicitly.

Controls



The `vmap0ui` screen lets you read data from the Vector Map Level 0 (VMAP0). The VMAP0 is the most detailed world map database available to the public.

You use the list to select the type of data and the map to select the region of interest. When you click the **Get** button, data is extracted and displayed on the map. Use the **Save** button to save the data in a MAT-file or to the base workspace for later display. The **Close** button closes the window.

The Map

The **Map** controls the geographic extent of the data to be extracted. `vmap0ui` extracts data for areas currently visible on the map. Use the mouse to zoom in or out to the area of interest. Type `help zoom` for more on zooming.

The VMAP0 divides the world into tiles of about 5–by–5 degrees. When extracting, data is returned for all visible tiles, including those parts of the tile that are outside the current view. The map shows the VMAP0 tiles in light yellow with light gray edges. The data density is high, so extracting data for a large number of tiles can take much time and memory. A count of the number of visible tiles is above the map.

The List

The **List** controls the type of data to be extracted. The tree structure of the list reflects the structure of the VMAP0 database. Upon starting `vmap0ui`, the list shows the major categories of VMAP data, called themes. Themes are subdivided into features, which consist of data of common graphic types (patch, line, point, or text) or cultural types (airport, roads, railroads). Double-click a theme to see the associated features. Features can have properties and values, for example, a railroad tracks property, with values single or multiple. Double-click a feature to see the associated properties and values. Double-clicking an open theme or feature closes it. When a theme is selected, `vmap0ui` gets all the associated features. When a feature is selected, `vmap0ui` gets all of that feature's data. When properties and values are selected, `vmap0ui` gets the data for any of the properties and values that match (that is, the union operation).

The Get Button

The **Get** button reads the currently selected VMAP0 data and displays it on the map. Use the **Cancel** button on the progress bar to interrupt the process. For a quicker response, press the standard interrupt key combination for your platform.

The Clear Button

The **Clear** button removes any previously read data from the map.

The Save Button

The **Save** button saves the currently displayed VMAP0 data to a MAT-file or the base workspace. If you choose to save to a file, you are prompted for a filename and location. If you choose to save to the

base workspace, you are notified of the variable names that will be overwritten.

Data are returned as Mapping Toolbox display structures with variable names based on theme and feature names. You can update vector display structures to geographic data structures. For information about display structure format, see "Version 1 Display Structures" on page 3-177 in the reference page for `displaym`. The `updategeostruct` function performs such conversions.

Use `load` and `displaym` to redisplay the data from a file on a map axes. You can also use the `mlayers` GUI to read and display the data from a file. To display the data in the base workspace, use `displaym`. To display all the display structures, use `rootlayr; displaym(ans)`. To display all of the display structures using the `mlayers` GUI, type `rootlayr; mlayers(ans)`.

The Close Button

The **Close** button closes the `vmap0ui` panel.

Examples

1. Launch `vmap0ui` and automatically detect a CD-ROM on Microsoft Windows:

   ```
   vmap0ui
   ```

2. Launch `vmap0ui` on Macintosh OS X (need to specify volume name):

   ```
   vmap0ui('Volumes/VMAP')
   ```

See also

`displaym`, `extractm`, `mlayers`, `vmap0data`

Purpose

GUI to adjust *z*-plane of mapped objects

Activation

Command Line
`zdatam`
`zdatam(h)`
`zdatam(str)`

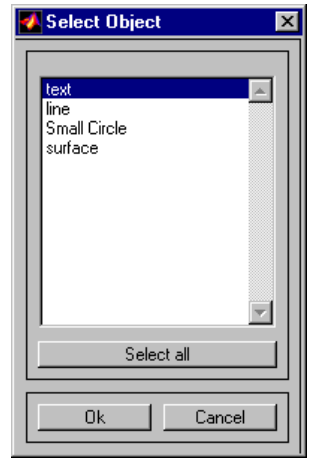
Description

`zdatam` brings up a Select Object dialog box for selecting mapped objects and adjusting their `ZData` property. Upon selecting the objects, the Specify Zdata dialog box is activated, in which the new `ZData` variable is entered. Note that not all mapped objects have the `ZData` property (for example text objects).

`zdatam(h)` activates the Specify Zdata dialog box for the objects specified by the handle `h`.

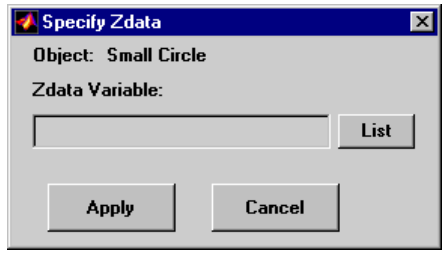
`zdatam(str)` activates the Specify Zdata dialog box for the objects identified by `str`, where `str` is any string recognized by `handlem`.

Controls



Select Object Dialog Box

The scroll box is used to select the desired objects from the list of mapped objects. Pushing the **Select all** button highlights all objects in the scroll box for selection. Pushing the **OK** button activates another Specify Zdata dialog box. Pushing the **Cancel** button aborts the operation without changing any properties of the selected objects.



Specify ZData Dialog Box

The **Zdata Variable** edit box is used to specify the name of the `ZData` variable. Pressing the **List** button produces a list of all current workspace variables, from which the `ZData` variable can be selected. A scalar value or a valid MATLAB expression can also be entered. Pressing the **Apply** button changes the `ZData` property of all selected objected to the new values. Pressing the **Cancel** button closes the Specify ZData dialog box without changing the `ZData` property of the selected objects.

See Also

`zdatam`

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