PV-WAVE *Advantage*™
PV-WAVE Command Language™

Reference
Volume 1

Version 4.2 • • •
2860
June 1993

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Contents Summary

Preface

The *PV-WAVE Reference* is a two-volume set that describes the PV-WAVE *Advantage* and CL functions and procedures, keywords, and system variables.

This reference is part of a larger set of documentation; the entire set is shown in Figure I. Start with the *PV-WAVE Tutorial*, and then refer to this reference for details about the basic elements of the PV-WAVE Command Language. You will also want to refer to the *PV-WAVE User's Guide for Advantage and CL* and the *PV-WAVE Programmer's Guide for Advantage and CL* for detailed information.

For your convenience, all of the documents shown in Figure I are available online, as well as being available in a hardcopy format. Additional copies of the hardcopy documentation can also be ordered from Visual Numerics, Inc., by calling 800/447-7147.

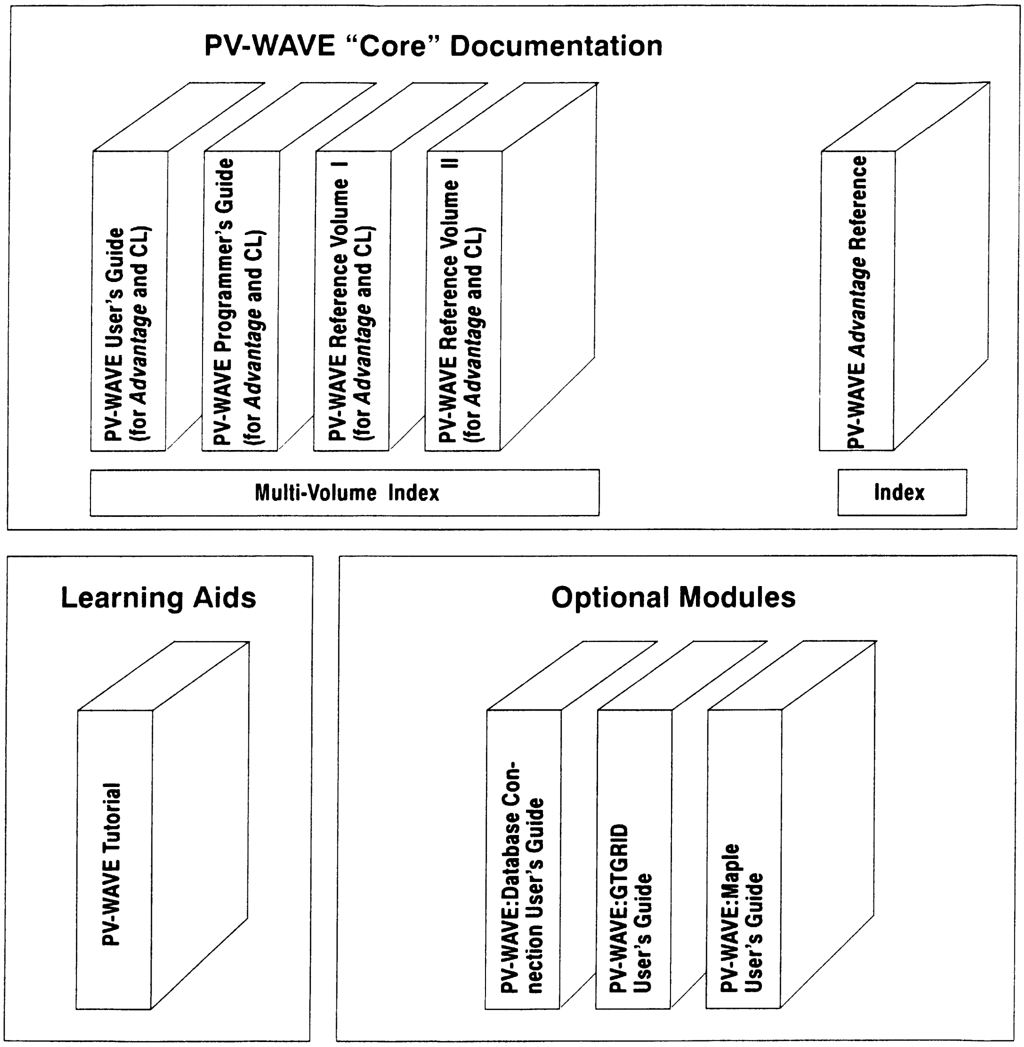
PV-WAVE "Core" Documentation
PV-WAVE User's Guide (for Advantage and CL)
PV-WAVE Programmer's Guide (for Advantage and CL)
PV-WAVE Reference Volume I (for Advantage and CL)
PV-WAVE Reference Volume II (for Advantage and CL)
PV-WAVE Advantage Reference
Multi-Volume Index
Index
Learning Aids
PV-WAVE Tutorial
Optional Modules
PV-WAVE:Database Connection User's Guide
PV-WAVE:GTGRID User's Guide
PV-WAVE:Maple User's Guide

Figure I PV-WAVE documentation set; for more information about any one book you see shown here, refer to its preface, where the contents of each chapter are explained briefly. All documents are available both online and in a hardcopy format. Additional copies of the hardcopy documentation can be ordered by calling Visual Numerics, Inc., at 303/447-7147.

Contents of this Reference

Volume 1 Contains:

- **Preface** — Describes the contents of this guide, lists the typographical conventions used, explains how to use the PV-WAVE documentation set, and explains how to obtain customer support.
- **Chapter 1: Functional Summary of Routines** — A handy listing of PV-WAVE functions and procedures arranged into functional groups, such as image processing routines, input/output routines, programming routines, and string processing routines. The basic syntax for each routine is also shown.
- **Chapter 2: Procedure and Function Reference: A – P** — An alphabetically arranged reference for all PV-WAVE procedures and functions. Most descriptions include one or more examples and cross references to related information.
- **Appendix A: Picture Index** — A graphical index of the illustrations that appear in the PV-WAVE documentation set.
- **Index** — A multivolume index that includes references to the *PV-WAVE User's Guide*, *PV-WAVE Programmer's Guide*, as well as both volumes of the *Reference.*

Volume 2 Contains:

- **Preface** — Describes the contents of this guide, lists the typographical conventions used, explains how to use the PV-WAVE documentation set, and explains how to obtain customer support.
- **Chapter 2 (Continued: Q – Z)** — Procedure and Function Reference.
- **Chapter 3: Graphics and Plotting Keywords** — Describes the keywords that can be used with the PV-WAVE graphics and plotting system routines.

- **Chapter 4: System Variables** – Describes each of the PV-WAVE system variables.
- **Chapter 5: Software Character Sets** – Shows each of the software character sets supported by PV-WAVE.
- **Appendix A: Picture Index** – A graphical index of the illustrations that appear in the PV-WAVE documentation set.
- **Index** – A multivolume index that includes references to the *PV-WAVE User's Guide*, *PV-WAVE Programmer's Guide*, as well as both volumes of the *Reference*.

Typographical Conventions

The following typographical conventions are used in this guide:

- PV-WAVE code examples appear `in this typeface`. For example:

  ```
  PLOT, temp, s02, Title='Air Quality'
  ```

- Code comments are shown in this typeface, below the commands they describe. For example:

  ```
  PLOT, temp, s02, Title='Air Quality'
  ```
    This command plots air temperature data vs. sulphur dioxide concentration.

  Comments are used often in this reference to explain code fragments and examples. Note that in actual PV-WAVE code, all comment lines must be preceded by a semicolon (;).

- PV-WAVE commands are not case sensitive. In this reference, variables are shown in lowercase italics (*myvar*), function and procedure names are shown in uppercase (XYOUTS), keywords are shown in mixed case italic (*XTitle*), and system variables are shown in regular mixed case type (!Version). For better readability, all widget routines are shown in mixed case (WwMainMenu).
- A `$` at the end of a PV-WAVE line indicates that the current statement is continued on the following line. By convention,

use of the continuation character ($) in this document reflects its syntactically correct use in PV-WAVE. This means, for instance, that *strings* are never split onto two lines without the addition of the string concatenation operator (+). For example, the following lines would produce an error if entered literally in PV-WAVE:

```
WAVE> PLOT, x, y, Title = 'Average $
   Air Temperatures by Two-Hour Periods'
```

Note that the string is split onto two lines; an error message is displayed if you enter a string this way.

The correct way to enter these lines is:

```
WAVE> PLOT, x, y , Title ='Average '+$
   'Air Temperatures by Two-Hour Periods'
```

This is the correct way to split a string onto two command lines.

- The | symbol means "or" when used in a usage line. It is not to be typed. For example, in the following command:

  result = QUERY_TABLE(*table*,
  ' [Distinct] * | col_i [*alias*] [, ..., col_n [*alias*]] ...

  the | means use either * or col_i [*alias*] [, ..., col_n [*alias*]], but not both.

- Reserved words, such as FOR, IF, CASE, are always shown in uppercase.

Customer Support

If you have problems unlocking your software or running the license manager, you can talk to a Visual Numerics Customer Support Engineer. The Customer Support group researches and answers your questions about all Visual Numerics products.

Please be prepared to provide Customer Support with the following information when you call:

- The name and version number of the product. For example, PV-WAVE 4.2 or PV-WAVE P&C 2.0.
- Your license number, or reference number if you are an Evaluation site.
- The type of system on which the software is being run. For example, Sun-4, IBM RS/6000, HP 9000 Series 700.
- The operating system and version number. For example, SunOS 4.1.3.
- A detailed description of the problem.

The phone number for the Customer Support group is 303/530-5200.

Trademark Information

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CHAPTER

Functional Summary of Routines

This chapter lists the following groups of related routines:

- *Plotting Routines* on page 16
- *Programming Routines* on page 18
- *Session Routines* on page 19
- *Special Mathematical Functions* on page 19
- *String Processing Routines* on page 20
- *Table Manipulation Functions* on page 20
- *Transcendental Mathematical Functions* on page 20
- *Window Routines* on page 21
- *WAVE Widgets Routines* on page 24
- *Widget Toolbox Routines* on page 25
- *Concurrent Processing Routines* on page 27

Array Creation Routines

BINDGEN(dim_1 [, dim_2, ... , dim_n])

Returns a byte array with the specified dimensions, setting the contents of the result to increasing numbers starting at 0.

BYTARR(dim_1 [, dim_2, ... , dim_n])

Returns a byte vector or array.

CINDGEN(dim_1 [, dim_2 , ... , dim_n])

Returns a complex single-precision floating-point array.

COMPLEXARR(dim_1 [, dim_2, ... , dim_n])

Returns a complex single-precision floating-point vector or array.

DBLARR(dim_1, ... , dim_n)

Returns a double-precision floating-point vector or array.

DINDGEN(dim_1, ..., dim_n)

Returns a double-precision floating-point array with the specified dimensions.

FINDGEN(dim_1, ..., dim_n)

Returns a single-precision floating-point array with the specified dimensions.

FLTARR(dim_1, ..., dim_n)

Returns a single-precision floating-point vector or array.

INDGEN(dim_1, ... , dim_n)

Returns an integer array with the specified dimensions.

INTARR(dim_1, ... , dim_n)

Returns an integer vector or array.

LINDGEN(dim_1, ... , dim_n)

Returns a longword integer array with the specified dimensions.

LONARR(dim_1, ... , dim_n)

Returns a longword integer vector or array.

MAKE_ARRAY([dim_1,... , dim_n])

Returns an array of specified type, dimensions, and initialization. It provides the ability to create an array dynamically whose characteristics are not known until run time.

REPLICATE(value, dim_1, ..., dim_n)

Forms an array with the given dimensions, filled with the specified scalar value.

SINDGEN(dim_1, ... , dim_n)

Returns a string array with the specified dimensions.

STRARR(dim_1, ... , dim_n)

Returns a string array.

Array Manipulation Routines

AVG(array [, dim])

Standard Library function that returns the average value of an array. Optionally, it can return the average value of one dimension of an array.

BILINEAR(array, x, y)

Standard Library function that creates an array containing values calculated using a bilinear interpolation to solve for requested points interior to an input grid specified by the input array.

CORRELATE(x, y)

Standard Library function that calculates a simple correlation coefficient for two arrays.

DETERM(array)

Standard Library function that calculates the determinant of a square, two-dimensional input variable.

HISTOGRAM(array)

Returns the density function of an array.

MAX(array [, max_subscript])

Returns the value of the largest element in an input array.

MEDIAN(array [, width])

Finds the median value of an array, or applies a one- or two- dimensional median filter of a specified width to an array.

MIN(array [, min_subscript])

Returns the value of the smallest element in array.

REBIN(array, dim_1, ..., dim_n)

Returns a vector or array resized to the given dimensions.

REFORM(array, dim_1, ... , dim_n)

Reformats an array without changing its values numerically.

REVERSE(array, dimension)

Standard Library function that reverses a vector or array for a given dimension.

ROTATE(array, direction)

Returns a rotated and/or transposed copy of the input array.

SHIFT(array, $shift_1$, ... , $shift_n$)

Shifts the elements of a vector or array along any dimension by any number of elements.

SIGMA(array [, npar, dim])

Standard Library function that calculates the standard deviation value of an array.

SMOOTH(array, width)

Smooths an array with a boxcar average of a specified width.

SORT(array)

Sorts the contents of an array.

STDEV(array [, mean])

Standard Library function that computes the standard deviation and (optionally) the mean of the input array.

TOTAL(array)

Sums the elements of an input array.

TRANSPOSE(array)

Transposes the input array.

WHERE(array_expr [, count])

Returns a longword vector containing the one-dimensional subscripts of the non-zero elements of the input array.

Data Connection Routines

DC_ERROR_MSG(status)

Returns the text string associated with the negative status code generated by a "DC" data import/export function that does not complete successfully.

DC_OPTIONS(msg_level)

Sets the error message reporting level for all "DC" import/export functions.

DC_READ_FIXED(filename, var_list)

Reads fixed-formatted ASCII data using a PV-WAVE CL format that you specify.

DC_READ_FREE(filename, var_list)

Reads freely-formatted ASCII files.

DC_READ_TIFF(filename, imgarr)

Reads a Tag Image File Format (TIFF) file.

DC_READ_8_BIT(filename, imgarr)

Reads an 8-bit image file.

DC_READ_24_BIT(filename, imgarr)

Reads a 24-bit image file.

DC_WRITE_FIXED(filename, var_list, format)

Writes the contents of one or more PV-WAVE CL variables (in ASCII fixed format) to a file using a format that you specify.

DC_WRITE_FREE(filename, var_list)

Writes the contents of one or more PV-WAVE CL variables to a file in ASCII free format.

DC_WRITE_TIFF(filename, imgarr)

Writes image data to a file using the Tag Image File Format (TIFF) format.

DC_WRITE_8_BIT(filename, imgarr)

Writes 8-bit image data to a file.

DC_WRITE_24_BIT(filename, imgarr)

Writes 24-bit image data to a file.

Data Conversion Routines

BYTE(expr)

Converts an expression to byte data type.

BYTSCL(array)

Scales and converts an array to byte data type.

COMPLEX(real [, imaginary])

Converts an expression to complex data type.

DOUBLE(expr)

Converts an expression to double-precision floating-point data type.

FIX(expr)

Converts an expression to integer data type.

FLOAT(expr)

Converts an expression to single-precision floating-point data type.

LONG(expr)

Converts an expression to longword integer data type.

STRING($expr_1$, ... , $expr_n$)

Converts the input parameters to characters and returns a string expression.

Data Extraction Routines

BYTE(expr, offset [, dim1, ... , dimn])

Extracts data from an expression and places it in a byte scalar or array.

COMPLEX(expr, offset, dim1 [, dim2, ... , dimn])

Extracts data from an expression and places it in a complex scalar or array.

DOUBLE(expr, offset, dim1 [, ..., dimn])

Extracts data from an expression and places it in a double- precision floating-point scalar or array.

FIX(expr, offset, dim1 [, ..., dimn])

Extracts data from an expression and places it in a integer scalar or array.

FLOAT(expr, offset, dim1 [, ..., dimn])

Extracts data from an expression and places it in a single- precision floating-point scalar or array.

LONG(expr, offset, dim1 [, ... , dimn])

Extracts data from an expression and places it in a longword integer scalar or array.

Date/Time Functions

CREATE_HOLIDAYS, dt_list

Creates the system variable !Holiday_List.

CREATE_WEEKENDS, day_names

Creates the system variable !Weekend_List.

DAY_NAME(dt_var)

Returns a string array containing the name of the day of the week for each day in a Date/Time variable.

DAY_OF_WEEK(dt_var)

Returns an array of integers containing the day of the week for each date in a Date/Time variable.

DAY_OF_YEAR(dt_var)

Returns an array of integers containing the day of the year for each date in a Date/Time variable.

DT_ADD(dt_value)

Increment the values in a Date/Time variable by a specified amount.

DT_COMPRESS(dt_array)

Removes holidays and weekends from the Julian day portion of Date/Time variables.

DT_DURATION(dt_value_1, dt_value_2)

Determines the elapsed time between two Date/Time variables.

DT_PRINT, dt_var

Prints the values of PV-WAVE CL Date/Time variables in a readable manner.

DT_SUBTRACT(dt_value)

Decrements the values in a Date/Time variable by a specified amount.

DT_TO_SEC(dt_value)

Converts PV-WAVE CL Date/Time variables into string data.

DT_TO_STR, dt_var, [, dates] [, times]

Converts PV-WAVE CL Date/Time variables into string data.

DT_TO_VAR, dt_value

Converts a PV-WAVE CL Date/Time variable to regular numerical data.

DTGEN(dt_start, dimension)

Returns an array of PV-WAVE CL Date/Time variables beginning from a specified date and incremented by a specified amount.

JUL_TO_DT(julian_day)

Converts a Julian day number to a PV-WAVE CL Date/Time variable.

LOAD_HOLIDAYS

Passes the value of the !Holiday_List system variable to the Date/Time routines.

LOAD_WEEKENDS

Passes the value of the !Weekend_List system variable to the Date/Time routines.

MONTH_NAME(dt_var)

Returns a string or array of strings containing the names of the months contained in a Date/Time variable.

SEC_TO_DT(num_of_seconds)

Converts any number of seconds into PV-WAVE CL Date/Time variables.

STR_TO_DT(date_strings [,time_strings])

Converts date and time string data to PV-WAVE CL Date/Time variables.

TODAY()

Returns a Date/Time variable containing the current system date and time.

VAR_TO_DT(yyyy, mm, dd, hh, mn, ss)

Converts scalars or arrays of scalars representing dates and times into PV-WAVE CL Date/Time variables.

File Manipulation Routines

CLOSE[, unit_1, ... , unit_n]

Closes the specified file units.

EOF(unit)

Tests the specified file unit for the end-of-file condition.

FINDFILE(file_specification)

Returns a string array containing the names of all files matching a specified file description.

FLUSH, unit_1, ..., unit_n

Causes all buffered output on the specified file units to be written.

FREE_LUN, unit_1, ..., unit_n

Deallocates file units previously allocated with GET_LUN.

FSTAT(unit)

Returns an expression containing status information about a specified file unit.

GET_LUN, unit

Allocates a file unit from a pool of free units.

OPENR, unit, filename [, record_length]

OPENR (OPEN Read) opens an existing file for input only.

OPENU, unit, filename [, record_length]

OPENU (OPEN Update) opens an existing file for input and output.

OPENW, unit, filename [, record_length]

OPENW (OPEN Write) opens a new file for input and output.

POINT_LUN, unit, position

Allows the current position of the specified file to be set to any arbitrary point in the file.

General Graphics Routines

CURSOR, x, y [, wait]

Reads the position of the interactive graphics cursor from the current graphics device.

DEVICE

Provides device-dependent control over the current graphics device (as specified by the SET_PLOT procedure).

EMPTY

Causes all buffered output for the current graphics device to be written.

ERASE [, background_color]

Erases the display surface of the currently active window.

GRID(xtmp, ytmp, ztmp)

Standard Library function that generates a uniform grid from irregularly-spaced data.

IMAGE_CONT, array

Standard Library procedure that overlays a contour plot onto an image display of the same array.

MOVIE, images [, rate]

Standard Library procedure that shows a cyclic sequence of images stored in a three-dimensional array.

PLOTS, x [, y [, z]]

Plots vectors or points on the current graphics device in either two or three dimensions.

POLYCONTOUR, filename

Standard Library procedure that shades enclosed contours with specified colors.

PROFILE(image)

Standard Library function that extracts a profile from an image.

PROFILES, image

Standard Library procedure that lets you interactively draw row or column profiles of the image displayed in the current window. The profiles are displayed in a new window, which is deleted when you exit the procedure.

RDPIX, image [, x0, y0]

Standard Library procedure that displays the X, Y, and pixel values at the location of the cursor in the image displayed in the currently active window.

SCALE3D

Standard Library procedure that scales a three-dimensional unit cube into the viewing area.

SET_PLOT, device

Specifies the device type used by PV-WAVE CL graphics procedures.

SHOW3, array

Standard Library procedure that displays a two-dimensional array as a combination contour, surface, and image plot. The resulting display shows a surface with an image underneath and a contour overhead.

T3D

Standard Library procedure that accumulates one or more sequences of translation, scaling, rotation, perspective, or oblique transformations and stores the result in the system variable !P.T.

THREED, array [, space]

Standard Library procedure that plots a two-dimensional array as a pseudo three-dimensional plot on the currently selected graphics device.

TVCRS [, on_off]

Manipulates the cursor within a displayed image, allowing it to be enabled and disabled, as well as positioned.

XYOUTS, x, y, string

Draws text on the currently selected graphics device starting at the designated data coordinate.

ZOOM

Expands and displays part of an image (or graphic plot) from the current window in a second window.

General Mathematical Functions

ABS(x)

Returns the absolute value of x.

AVG(array [, dim])

Standard Library function that returns the average value of an array. Optionally, it can return the average value of one dimension of an array.

BILINEAR(array, x, y)

Standard Library function that creates an array containing values calculated using a bilinear interpolation to solve for requested points interior to an input grid specified by the input array.

CHECK_MATH([print_flag, message_inhibit])

Returns and clears the accumulated math error status.

CONJ(x)

Returns the complex conjugate of the input variable.

CONVOL(array, kernel [, scale_factor])

Convolves an array with a kernel (or another array).

CORRELATE(x, y)

Standard Library function that calculates a simple correlation coefficient for two arrays.

CROSSP(v_1, v_2)

Standard Library function that returns the cross product of two three-element vectors.

CURVEFIT(x, y, wt, parms, [sigma])

Standard Library function that performs a nonlinear least-squares fit to a function of an arbitrary number of parameters.

DERIV([x,] y)

Standard Library function that calculates the first derivative of a function in x and y.

DETERM(array)

Standard Library function that calculates the determinant of a square, two-dimensional input variable.

FFT(array, direction)

Returns the Fast Fourier Transform for the input variable.

FINITE(x)

Returns a value indicating if the input variable is finite or not.

GAUSSFIT(x, y [, coefficients])

Standard Library function that fits a Gaussian curve through a data set.

HILBERT(x [, d])

Standard Library function that constructs a Hilbert transformation matrix.

IMAGINARY(complex_expr)

Returns the imaginary part of a complex number.

INVERT(array [, status])

Returns an inverted copy of a square array.

ISHFT(p_1, p_2)

Performs the bit shift operation on bytes, integers, and longwords.

LUBKSB, a, index, b

Solves the set of n linear equations Ax =b. (LUBKSB must be used with the procedure LUDCMP to do this.)

LUDCMP, a, index, d

Replaces an n-by-n matrix, a, with the LU decomposition of a row-wise permutation of itself.

MPROVE, a, alud, index, b, x

Iteratively improves the solution vector, x, of a linear set of equations, Ax =b. (You must call the LUDCMP procedure before calling MPROVE.)

POLY(x, coefficients)

Standard Library function that evaluates a polynomial function of a variable.

POLY_AREA(x, y)

Standard Library function that returns the area of an n-sided polygon, given the vertices of the polygon.

POLY_FIT(x, y, deg [, yft, ybd, sig, mat])

Standard Library function that fits an n-degree polynomial curve through a set of data points using the least-squares method.

POLYFITW(x, y, wt, deg [, yft, ybd, sig, mat])

Standard Library function that fits an n-degree polynomial curve through a set of data points using the least-squares method.

RANDOMN(seed [, $\dim_1$, ... , $\dim_n$])

Returns one or more normally distributed floating-point pseudo-random numbers with a mean of zero and a standard deviation of 1.

RANDOMU(seed [, $\dim_1$, ... , $\dim_n$])

Returns one or more uniformly distributed floating-point pseudo-random numbers over the range 0 < Y < 1.0.

REGRESS(x, y, wt [, yf, a0, sig, ft, r, rm, c])

Standard Library function that fits a curve to data using the multiple linear regression method.

SIGMA(array [, npar, dim])

Standard Library function that calculates the standard deviation value of an array. (Optionally, it can also calculate the standard deviation over one dimension of an array as a function of the other dimensions.)

SOBEL(image)

Performs a Sobel edge enhancement of an image.

SPLINE(x, y, t [, tension])

Standard Library function that performs a cubic spline interpolation.

STDEV(array [, mean])

Standard Library function that computes the standard deviation and (optionally) the mean of the input array.

SURFACE_FIT(array, degree)

Standard Library function that determines the polynomial fit to a surface.

SVBKSB, u, w, v, b, x

Uses "back substitution" to solve the set of simultaneous linear equations Ax = b, given the u, w, and v arrays created by the SVD procedure from the matrix a.

SVD, a, W [, u [, v]]

Performs a singular value decomposition on a matrix.

SVDFIT(x, y, m)

Standard Library function that uses the singular value decomposition method of least-squares curve fitting to fit a polynomial function to data.

TQLI, d, e, z

Uses the QL algorithm with implicit shifts to determine the eigenvalues and eigenvectors of a real, symmetric, tridiagonal matrix.

TRED2, a [, d [, e]]

Reduces a real, symmetric matrix to tridiagonal form, using Householder's method.

TRIDAG, a, b, c, r, u

Solves tridiagonal systems of linear equations.

ZROOTS, a, roots [, polish]

Finds the roots of the m-degree complex polynomial, using Laguerre's method.

Help and Information Routines

DOC_LIBRARY [, name]

Standard Library procedure that extracts header documentation for user-written PV-WAVE CL procedures and functions.

INFO, $expr_1$, ... , $expr_n$

Displays information on many aspects of the current PV-WAVE CL session.

Image Display Routines

ADJCT

Standard Library procedure that lets you interactively change the range and lower limit of the current color table.

C_EDIT [, colors_out]

Standard Library procedure that lets you interactively create a new color table based on the HLS or HSV color system.

COLOR_CONVERT, i_0, i_1, i_2, o_0, o_1, o_2, keyword

Converts colors to and from the RGB color system and either the HLS or HSV systems.

COLOR_EDIT [, colors_out]

Standard Library procedure that lets you interactively create color tables based on the HLS or HSV color system.

COLOR_PALETTE

Standard Library procedure that displays the current color table colors and their associated color table indices.

HIST_EQUAL_CT [, image]

Standard Library procedure that uses an input image parameter, or the region of the display you mark, to obtain a pixel distribution histogram. The cumulative integral is taken and scaled, and the result is applied to the current color table.

HLS, ltlo, lthi, stlo, sthi, hue, lp [, rgb]

Standard Library procedure that generates and loads color tables into an image display device based on the HLS color system. The resulting color table is loaded into the display system.

HSV, vlo, vhi, stlo, sthi, hue, lp [, rgb]

Standard Library procedure that generates and loads color tables into an image display device based on the HSV color system. The final color table is loaded into the display device.

LOADCT [, table_number]

Standard Library procedure that loads a predefined PV-WAVE CL color table.

MODIFYCT, table, name, red, green, blue

Standard Library procedure that lets you replace one of the PV-WAVE CL color tables (defined in the colors.tbl file) with a new color table.

PALETTE [, colors_out]

Standard Library procedure that lets you interactively create a new color table based on the RGB color system.

PSEUDO, ltlo, lthi, stlo, sthi, hue, lp [, rgb]

Standard Library procedure that creates a pseudo color table based on the Hue, Lightness, Saturation (HLS) color system.

STRETCH, low, high

Standard Library procedure that linearly expands the range of the color table currently loaded to cover an arbitrary range of pixel values.

TV, image [, position]

Displays images without scaling the intensity.

TVCRS [, on_off]

Manipulates the cursor within a displayed image, allowing it to be enabled and disabled, as well as positioned.

TVLCT, v_1, v_2, v_3 [, start]

Loads the display color translation tables from the specified variables.

TVRD(x_0, y_0, n_x, n_y [, channel])

Returns the contents of the specified rectangular portion of a displayed image.

TVSCL, image [, x, y [, channel]]

Scales the intensity values of an input image into the range of the image display, usually from 0 to 255, and outputs the data to the image display at the specified location.

Image Processing Routines

CONGRID(image, col, row)

Standard Library function that shrinks or expands an image or array.

CONVOL(array, kernel [, scale_factor])

Convolves an array with a kernel (or another array).

DEFROI(sizex, sizey [, xverts, yverts])

Standard Library function that defines an irregular region of interest within an image by using the image display system and the mouse.

DIGITAL_FILTER(flow, fhigh, gibbs, nterm)

Standard Library function that constructs finite impulse response digital filters for signal processing.

DILATE(image, structure [, x0, y0])

Implements the morphologic dilation operator for shape processing.

DIST(n)

Standard Library function that generates a square array in which each element equals the euclidean distance from the nearest corner.

ERODE(image, structure [, x0, y0])

Implements the morphologic erosion operator for shape processing.

FFT(array, direction)

Returns the Fast Fourier Transform for the input variable.

HANNING(col [, row])

Standard Library function that implements a window function for Fast Fourier Transform signal or image filtering.

HIST_EQUAL(image)

Standard Library function that returns a histogram-equalized image or vector.

HISTOGRAM(array)

Returns the density function of an array.

IMAGE_CONT, array

Standard Library procedure that overlays a contour plot onto an image display of the same array.

LEEFILT(image [; n, sigma])

Standard Library function that performs image smoothing by applying the Lee Filter algorithm.

MEDIAN(array [, width])

Finds the median value of an array, or applies a one- or two- dimensional median filter of a specified width to an array.

MOVIE, images [, rate]

Standard Library procedure that shows a cyclic sequence of images stored in a three-dimensional array.

POLY_2D(array, coeff_x, coeff_y [, interp [, dim_x ,..., dim_y]])

Performs polynomial warping of images.

POLYFILLV(x, y, sx, sy [, run_length])

Returns a vector containing the subscripts of the array elements contained inside a specified polygon.

POLYWARP, xd, yd, xin, yin, deg, xm, ym

Standard Library procedure that calculates the coefficients needed for a polynomial image warping transformation.

PROFILE(image)

Standard Library function that extracts a profile from an image.

PROFILES, image

Standard Library procedure that lets you interactively draw row or column profiles of the image displayed in the current window. The profiles are displayed in a new window, which is deleted when you exit the procedure.

RDPIX, image [, x0, y0]

Standard Library procedure that displays the X, Y, and pixel values at the location of the cursor in the image displayed in the currently active window.

REBIN(array, dim_1, ..., dim_n)

Returns a vector or array resized to the given dimensions.

REFORM(array, dim_1, ... , dim_n)

Reformats an array without changing its values numerically.

ROBERTS(image)

Performs a Roberts edge enhancement of an image.

ROT(image, ang[, mag, xctr, yctr])

Standard Library function that rotates and magnifies (or demagnifies) a two-dimensional array.

ROT_INT(image, ang [, mag, xctr, yctr])

Standard Library function that rotates and magnifies (or demagnifies) an image on the display screen.

ROTATE(array, direction)

Returns a rotated and/or transposed copy of the input array.

SHIFT(array, $shift_1$, ... , $shift_n$)

Shifts the elements of a vector or array along any dimension by any number of elements.

SHOW3, array

Standard Library procedure that displays a two-dimensional array as a combination contour, surface, and image plot. The resulting display shows a surface with an image underneath and a contour overhead.

SMOOTH(array, width)

Smooths an array with a boxcar average of a specified width.

SOBEL(image)

Performs a Sobel edge enhancement of an image.

TRANSPOSE(array)

Transposes the input array.

ZOOM

Standard Library procedure that expands and displays part of an image (or graphic plot) from the current window in a second window.

Input and Output Routines

ASSOC(unit, array_structure [, offset])

Associates an array structure with a file, allowing random access input and output.

BYTEORDER, $variable_1$, ... , $variable_n$

Converts integers between host and network byte ordering. Can also be used to swap the order of bytes within both short and long integers.

GET_KBRD(wait)

Returns the next character available from standard input (PV-WAVE CL file unit 0).

LN03 [, filename]

Standard Library procedure that opens or closes an output file for LN03 graphics output. The file can then be printed on an LN03 printer.

PRINT, $expr_1$, ... , $expr_n$

PRINT performs output to the standard output stream (PV-WAVE CL file unit –1).

PRINTF, unit, $expr_1$, ... , $expr_n$

PRINTF requires the output file unit to be specified.

READ, var_1, ..., var_n

Read input from the standard input stream into PV-WAVE CL variables.

READF, unit, var_1, ... , var_n

Read input from a file into PV-WAVE CL variables.

READU, unit, var_1, ... , var_n

READU reads binary (unformatted) input from a specified file. (No processing of any kind is done to the data.)

REWIND, unit

(VMS Only) Rewinds the tape on the designated PV-WAVE CL tape unit.

SKIPF, unit, files

SKIPF, unit, records, r

(VMS Only) Skips records on the designated magnetic tape unit.

TAPRD, array, unit [, byte_reverse]

(VMS Only) Reads the next record on the selected tape unit into the specified array.

TAPWRT, array, unit [, byte_reverse]

(VMS Only) Writes data from the input array to the selected tape unit.

WRITEU, unit, expr_1, ... , expr_n

Writes binary (unformatted) data from an expression into a file.

Operating System Access Routines

CALL_UNIX(p_1 [, p_2, ... , p_{30}])

(UNIX Only) Lets a PV-WAVE CL procedure communicate with an external routine written in C.

CD [, directory]

Changes the current working directory.

DELETE_SYMBOL, name

(VMS Only) Deletes a DCL (Digital Command Language) interpreter symbol from the current process.

DELLOG, logname

(VMS Only) Deletes a logical name.

ENVIRONMENT( )

(UNIX Only) Returns a string array containing all the UNIX environment strings for the PV-WAVE CL process.

GETENV(name)

Returns the specified equivalence string from the environment of the PV-WAVE CL process.

GET_SYMBOL(name)

(VMS Only) Returns the value of a VMS DCL interpreter symbol as a scalar string.

LINKNLOAD(object, symbol [, param_1, ..., param_n])

Provides simplified access to external routines in shareable images.

POPD

Standard Library procedure that pops a directory from the top of a last-in, first-out directory stack.

PRINTD

Standard Library procedure that lists the directories located in the directory stack, and the current working directory.

PUSHD [, directory]

Standard Library procedure that pushes a directory onto the top of a last-in, first-out directory stack.

SETENV, environment_expr

(UNIX Only) Adds or changes an environment string in the process environment.

SETLOG, logname, value

(VMS Only) Defines a logical name.

SET_SYMBOL, name, value

(VMS Only) Defines a DCL interpreter symbol for the current process.

SPAWN [, command [, result]]

Spawns a child process to execute a given command.

SYSTIME(param)

Returns the current system time as either a string or as the number of seconds elapsed since January 1, 1970.

TRNLOG(logname, value)

(VMS Only) Searches the VMS name tables for a specified logical name and returns the equivalence string(s) in a PV-WAVE CL variable.

WEOF, unit

(VMS Only) Writes an end-of-file mark on the designated unit at the current position.

Plotting Routines

AXIS [[[, x], y], z]

Draws an axis of the specified type and scale at a given position.

CONTOUR, z [, x, y]

Draws a contour plot from data stored in a rectangular array.

CURSOR, x, y [, wait]

Reads the position of the interactive graphics cursor from the current graphics device.

ERRPLOT [, points], low, high

Standard Library procedure that overplots error bars over a previously-drawn plot.

GRID(xtmp, ytmp, ztmp)

Standard Library function that generates a uniform grid from irregularly-spaced data.

IMAGE_CONT, array

Standard Library procedure that overlays a contour plot onto an image display of the same array.

OPLOT, x [, y]

Plots vector data over a previously drawn plot.

OPLOTERR, x, y, error [, psym]

Standard Library procedure that overplots symmetrical error bars on any plot already output to the display device.

PLOT, x [, y]

PLOT produces a simple XY plot.

PLOT_IO, x [, y]

PLOT_IO produces an XY plot with logarithmic scaling on the Y axis.

PLOT_OI, x [, y]

PLOT_OI produces an XY plot with logarithmic scaling on the X axis.

PLOT_OO, x [, y]

PLOT_OO produces an XY plot with logarithmic scaling on both the X and Y axes.

PLOTERR, [x,] y, error

Standard Library procedure that plots data points with accompanying symmetrical error bars.

PLOT_FIELD, u, v

Standard Library procedure that plots a two-dimensional velocity field.

PLOTS, x [, y [, z]]

Plots vectors or points on the current graphics device in either two or three dimensions.

POLYCONTOUR, filename

Standard Library procedure that shades enclosed contours with specified colors.

POLYFILL, x [, y [, z]]

Fills the interior of a region of the display enclosed by an arbitrary two- or three-dimensional polygon.

POLYSHADE(vertices, polygons)

Constructs a shaded surface representation of one or more solids described by a set of polygons.

PROFILE(image)

Standard Library function that extracts a profile from an image.

PROFILES, image

Standard Library procedure that lets you interactively draw row or column profiles of the image displayed in the current window. The profiles are displayed in a new window, which is deleted when you exit the procedure.

SCALE3D

Standard Library procedure that scales a three-dimensional unit cube into the viewing area.

SET_SHADING

Modifies the light source shading parameters affecting the output of SHADE_SURF and POLYSHADE.

SHADE_SURF, z [, x, y]

Standard Library procedure that creates a shaded surface representation of a regular or nearly regular gridded surface, with shading from either a light source model or from a specified array of intensities.

SHADE_SURF_IRR, z [, x, y]

Creates a shaded-surface representation of a semiregularly gridded surface, with shading from either a light source model or from a specified array of intensities.

SHOW3, array

Standard Library procedure that displays a two-dimensional array as a combination contour, surface, and image plot. The resulting display shows a surface with an image underneath and a contour overhead.

SURFACE, z [, x, y]

Draws the surface of a two-dimensional array projected into two dimensions, with hidden lines removed.

T3D

Standard Library procedure that accumulates one or more sequences of translation, scaling, rotation, perspective, or oblique transformations and stores the result in the system variable !P.T.

THREED, array [, space]

Standard Library procedure that plots a two-dimensional array as a pseudo three-dimensional plot on the currently selected graphics device.

USERSYM, x [, y]

Lets you create a custom symbol for marking plotted points.

VEL, u, v

Standard Library procedure that draws a graph of a velocity field with arrows pointing in the direction of the field. The length of an arrow is proportional to the strength of the field at that point.

VELOVECT, u, v [, x, y]

Standard Library procedure that draws a two-dimensional velocity field plot, with each directed arrow indicating the magnitude and direction of the field.

Programming Routines

BREAKPOINT, file, line

Lets you insert and remove breakpoints in programs for debugging.

CHECK_MATH([print_flag, message_inhibit])

Returns and clears the accumulated math error status.

DEFINE_KEY, key [, value]

Programs a keyboard function key with a string value, or with a specified action.

DEFSYSV, name, value [, read_only]

Creates a new system variable initialized to the specified value.

DELFUNC, function$_i$,..., function$_n$

Deletes one or more compiled functions from memory.

DELPROC, procedure$_i$,..., procedure$_n$

Deletes one or more compiled procedures from memory.

DELSTRUCT, structure$_i$,..., structure$_n$

Deletes one or more named structure definitions from memory.

DELVAR, v_1, ... ,v_n

Deletes variables from the main program level.

EXIT

Exits PV-WAVE CL and returns you to the operating system.

FINITE(x)

Returns a value indicating if the input variable is finite or not.

HAK

Standard Library procedure that lets you implement a "hit any key to continue" function.

KEYWORD_SET(expr)

Tests if an input expression has a non-zero value.

MESSAGE, text

Issues error and informational messages using the same mechanism employed by built-in PV-WAVE CL routines.

N_ELEMENTS(expr)

Returns the number of elements contained in any expression or variable.

N_PARAMS( )

Returns the number of non-keyword parameters used in calling a PV-WAVE CL procedure or function.

N_TAGS(expr)
: Returns the number of structure tags contained in any expression.

ON_ERROR, n
: Determines the action taken when an error is detected inside a PV-WAVE CL user-written procedure or function.

ON_IOERROR, label
: Specifies a statement to jump to if an I/O error occurs in the current procedure.

RETALL
: Issues RETURNs from nested routines. Used primarily to recover from errors in user-written procedures and functions.

RETURN [, expr]
: Returns control to the caller of a user-written procedure or function.

SIZE(expr)
: Returns a vector containing size and type information for the given expression.

STOP [, expr_1,... , expr_n]
: Stops the execution of a running program or batch file, and returns control to the interactive mode.

STRMESSAGE(errno)
: Returns the text of the error message specified by the input error number.

STRUCTREF({structure})
: Returns a list of all existing references to a structure.

TAG_NAMES(expr)
: Returns a string array containing the names of the tags in a structure expression.

TVMENU(text [, title, x, y])
: Standard Library procedure that creates an interactive menu.

WAIT, seconds
: Suspends execution of a PV-WAVE CL program for a specified period.

Session Routines

INFO, expr_1, ... , expr_n
: Displays information on many aspects of the current PV-WAVE CL session.

JOURNAL [, param]
: Provides a record of an interactive session by saving in a file all text entered from the terminal in response to a prompt.

RESTORE [, filename]
: Restores the PV-WAVE CL objects saved in a file by the SAVE procedure.

SAVE [, var_1, ... , var_n]
: Saves variables in a file for later recovery by RESTORE.

Special Mathematical Functions

BESELI(x [, n])
: Calculates the Bessel I function for the input parameter.

BESELJ(x [, n])
: Calculates the Bessel J function for the input parameter.

BESELY(x [, n])

Calculates the Bessel Y function for the input parameter.

ERRORF(x)

Calculates the standard error function of the input variable.

GAMMA(x)

Calculates the gamma function of the input variable.

GAUSSINT(x)

Evaluates the integral of the Gaussian probability function.

String Processing Routines

STRCOMPRESS(string)

Compresses the white space in an input string.

STRLEN(expr)

Returns the length of the input parameter.

STRLOWCASE(string)

Converts a copy of the input string to lowercase letters.

STRMID(expr, first_character, length)

Extracts a substring from a string expression.

STRPOS(object, search_string [, position])

Searches for the occurrence of a substring within an object string, and returns its position.

STRPUT, destination, source [, position]

Inserts the contents of one string into another.

STRTRIM(string [, flag])

Removes extra blank spaces from an input string.

STRUPCASE(string)

Converts a copy of the input string to uppercase letters.

Table Manipulation Functions

BUILD_TABLE(' var_i [alias], ..., var_n [alias] ')

Creates a table from one or more vectors (one-dimensional arrays).

QUERY_TABLE(table, ' [Distinct] * | col_i [alias] [, ..., col_n [alias]] [Where cond] [Group By colg_i [,... colg_n]] | [Order By colo_i [direction][,..,colo_n [direction]]] ')

Subsets a table created with the BUILD_TABLE function.

UNIQUE(vec)

Returns a vector (one-dimensional array) containing the unique elements from another vector variable.

Transcendental Mathematical Functions

ACOS(x)

Returns the arc-cosine of x.

ALOG(x)

Returns the natural logarithm of x.

ALOG10(x)

Returns the logarithm to the base 10 of x.

ASIN(x)

Returns the arcsine of x.

ATAN(x [, y])

Calculates the arctangent of the input variable(s).

COS(x)

Calculates the cosine of the input variable.

COSH(x)

Calculates the hyperbolic cosine of the input variable.

EXP(x)

Raises e to the power of the value of the input variable.

SIN(x)

Returns the sine of the input variable.

SINH(x)

Returns the hyperbolic sine of the input variable.

SQRT(x)

Calculates the square root of the input variable.

TAN(x)

Returns the tangent of the input variable.

TANH(x)

Returns the hyperbolic tangent of the input variable.

Window Routines

TVMENU(text [, title, x, y])

Standard Library procedure that creates an interactive menu.

WDELETE [, window_index]

Deletes the specified window.

WINDOW [, window_index]

Creates a window for the display of graphics or text.

WMENU(strings)

Displays a menu inside the current window whose choices are given by the elements of a string array and which returns the index of the user's response.

WSET [, window_index]

Used to select the current window to be used by the graphics and imaging routines.

WSHOW [, window_index [, show]]

Exposes or hides the designated window. It does not automatically make the designated window the active window.

Coordinate Conversion Routines

CONV_FROM_RECT(vec1, vec2, vec3)

Converts rectangular coordinates (points) to polar, cylindrical, or spherical coordinates.

CONV_TO_RECT(vec1, vec2, vec3)

Converts polar, cylindrical, or spherical coordinates to rectangular coordinates (points).

POLY_DEV(points, winx, winy)

Returns a list of 3D points converted from normal coordinates to device coordinates.

POLY_NORM(points)

Returns a list of 3D points converted from data coordinates to normal coordinates.

POLY_TRANS(points, trans)

Returns a list of 3D points transformed by a 4-by-4 transformation matrix.

Gridding Routines

FAST_GRID2(points, grid_x)

Returns a gridded, 1D array containing Y values, given random X,Y coordinates (this function works best with dense data points).

FAST_GRID3(points, grid_x, grid_y)

Returns a gridded, 2D array containing Z values, given random X, Y, Z coordinates (this function works best with dense data points).

FAST_GRID4(points, grid_x, grid_y, grid_z)

Returns a gridded, 3D array containing intensity values, given random 4D coordinates (this function works best with dense data points).

GRID(xtmp, ytmp, ztmp)

Standard Library function that generates a uniform grid from irregularly-spaced data.

GRID_2D(points, grid_x)

Returns a gridded, 1D array containing Y values, given random X,Y coordinates (this function works best with sparse data points).

GRID_3D(points, grid_x, grid_y)

Returns a gridded, 2D array containing Z values, given random X, Y, Z coordinates (this function works best with sparse data points).

GRID_4D(points, grid_x, grid_y, grid_z)

Returns a gridded, 3D array containing intensity values, given random 4D coordinates (this function works best with sparse data points).

GRID_SPHERE(points, grid_x, grid_y)

Returns a gridded, 2D array containing radii, given random longitude, latitude, and radius values.

Polygon Generation Routines

POLY_SPHERE, radius, px, py, vertex_list, polygon_list

Generates the vertex list and polygon list that represent a sphere.

POLY_SURF, surf_dat, vertex_list, polygon_list, pg_num

Generates a 3D vertex list and a polygon list, given a 2D array containing Z values.

SHADE_VOLUME, volume, value, vertex, poly

Given a 3D volume and a contour value, produces a list of vertices and polygons describing the contour surface (also known as an iso-surface).

Polygon Manipulation Routines

POLY_C_CONV(polygon_list, colors)

Returns a list of colors for each polygon, given a polygon list and a list of colors for each vertex.

POLY_COUNT(polygon_list)

Returns the total number of polygons contained in a polygon list.

POLY_MERGE, vertex_list1, vertex_list2, polygon_list1, polygon_list2, vert, poly, pg_num

Merges two vertex lists and two polygon lists together so that they can be rendered in a single pass.

Polygon Rendering Routines

POLY_PLOT, vertex_list, polygon_list, pg_num, winx, winy, fill_colors, edge_colors, poly_opaque

Renders a given list of polygons.

POLYSHADE(vertices, polygons)

POLYSHADE(x, y, z, polygons)

Constructs a shaded surface representation of one or more solids described by a set of polygons.

RENDER(object1, ..., objectn)

Generates a ray-traced rendered image from one or more predefined objects.

Ray Tracing Routines

CONE( )

Defines a conic object that can be used by the RENDER function.

CYLINDER( )

Defines a cylindrical object that can be used by the RENDER function.

MESH(vertex_list, polygon_list)

Defines a polygonal mesh object that can be used by the RENDER function.

RENDER(object1, ..., objectn)

Generates a ray-traced rendered image from one or more predefined objects.

SPHERE( )

Defines a spherical object that can be used by the RENDER function.

VOLUME(voxels)

Defines the volumetric data that can be used by the RENDER function.

View Setup Routines

CENTER_VIEW

Sets system viewing parameters to display data in the center of the current window (a convenient way to set up a 3D view).

SET_VIEW3D, viewpoint, viewvector, perspective, izoom, viewup, viewcenter, winx, winy, xr, yr, zr

Generates a 3D view, given a view position and a view direction.

T3D

Standard Library procedure that accumulates one or more sequences of translation, scaling, rotation, perspective, or oblique transformation and stores the results in the system variable !P.T.

VIEWER, win_num, xsize, ysize, size_fac, xpos, ypos, colors, retain, xdim, ydim, zdim

Lets users interactively define a 3D view, a slicing plane, and multiple cut-away volumes for volume rendering. (Creates a View Control and a View Orientation window in which to make these definitions.)

Volume Manipulation Routines

SLICE_VOL(volume, dim, cut_plane)

Returns a 2D array containing a slice from a 3D volumetric array.

VOL_PAD(volume, pad_width)

Returns a 3D volume of data padded on all six sides with zeroes.

VOL_TRANS(volume, dim, trans)

Returns a 3D volume of data transformed by a 4-by-4 matrix.

Volume Rendering Routines

RENDER(object1, ..., objectn)

Generates a ray-traced rendered image from one or more predefined objects.

VECTOR_FIELD3, vx, vy, vz, n_points

Plots a 3D vector field from three arrays.

VOL_MARKER, vol, n_points

Displays colored markers scattered throughout a volume.

VOL_REND(volume, imgx, imgy)

Renders volumetric data in a translucent manner.

WAVE Widgets Routines

WwButtonBox(parent, labels, callback)

Creates a horizontally or vertically oriented box containing push buttons.

WwCommand(parent, enteredCallback, doneCallback)

Creates a command window.

WwControlsBox(parent, labels, range, changedCallback)

Creates a box containing sliders.

WwDialog(parent, label, OKCallback, CancelCallback, HelpCallback)

Creates a blocking or nonblocking dialog box.

WwDrawing(parent, windowid, drawCallback, wsize, dsize)

Creates a drawing area, which allows users to display graphics generated by PV-WAVE.

WwFileSelection(parent, OKCallback, CancelCallback, HelpCallback)

Creates a file selection widget, which lets the user display the contents of directories and select files.

WwGetValue(widget)

Returns a specific value for a given widget.

WwInit(app_name, appclass_name, workarea[, destroyCallback])

Initializes the WAVE Widgets environment, opens the display, creates the first top-level shell, and creates a layout widget.

WwLayout(parent)

Creates a layout widget that is used to control the arrangement of other widgets.

WwList(parent, items, selectedCallback, defaultCallback)

Creates a scrolling list widget.

WwLoop

Handles the dispatching of events and calling of PV-WAVE callbacks.

WwMainWindow(parent, workarea, [destroyCallback])

Creates a top-level window and a layout widget.

WwMenuBar(parent, items)

Creates a menu bar.

WwMenuItem(parent, item, value [, callback])

Adds, modifies, or deletes specified menu items.

WwMessage(parent, label, OKCallback, CancelCallback, HelpCallback)

Creates a blocking or nonblocking message box.

WwOptionMenu(parent, label, items)

Creates an option menu.

WwPopupMenu(parent, items)

Creates a popup menu.

WwRadioBox(parent, labels, callback)

Creates a box containing radio buttons.

WwSetValue(widget, [value])

Sets the specified value for a given widget.

WwTable(parent, callback [, variable])

Creates an editable 2D array of cells containing string data, similar to a spreadsheet.

WwText(parent, verifyCallback)

Creates a text widget that can be used for both single-line text entry or as a full text editor. In addition, this function can create a static text label.

WwToolBox(parent, labels, callback)

Creates an array of graphic buttons (icons).

Widget Toolbox Routines

WtAddCallback(widget, reason, callback [, client_data])

Registers a PV-WAVE callback routine for a given widget.

WtAddHandler(widget, eventmask, handler [, client_data])

Registers the X event handler function for a given widget.

WtClose(widget)

Closes the current Xt (OLIT or Motif) session, and destroys all children of the top-level widget created in WtInit. This routine can also be used to destroy additional widget trees.

WtCreate(name, class, parent [, argv])

Creates a widget or shell instance specified by widget class.

WtCursor(function, widget [, index])

Sets or changes the cursor.

WtGet(widget [, resource])

Retrieves widget resources.

WtInit(app_name, appclass_name [, Xserverargs ...])

Initializes the Widget Toolbox and the Xt toolkit, opens the display, and creates the first top-level shell.

WtInput(function [, parameters])

Registers a PV-WAVE input source handler procedure.

WtList(function, widget [, parameters])

Controls the characteristics of scrolling list widgets.

WtLoop

Handles the dispatching of events and calling of PV-WAVE callback routines.

WtMainLoop

Handles the dispatching of events.

WtPointer(function, widget [, parameters])

The pointer utility function.

WtSet(widget, argv)

Sets widget resources.

WtTable(function, widget [, parameters])

Modifies an xbaeMatrix class widget.

WtTimer(function, params, [client_data])

Registers a callback function for a given timer.

WtWorkProc(function, parameters)

Registers a PV-WAVE work procedure for background processing.

WAVE Widget Utilities

WgAnimateTool, image_data [, parent [, shell]]

Creates a window for animating a sequence of images.

WgCbarTool [,*parent* [, *shell* [, *windowid* [, *movedCallback*], [, *range*]]]]]

Creates a simple color bar that can be used to view and interactively shift a PV-WAVE color table.

WgCeditTool [, parent [, shell]]

Creates a full-featured set of menus and widgets enclosed in a window; this window allows you to edit the values in PV-WAVE color tables in many different ways.

WgCtTool [, parent [, shell]]

Creates a simple widget that can be used interactively to modify a PV-WAVE color table.

WgIsoSurfTool, surface_data [, parent [, shell]]

Creates a window with a built-in set of controls; these controls allow you to easily view and modify an iso-surface taken from a three-dimensional block of data.

WgMovieTool, image_data [, parent [, shell [, windowid [, rate]]]]

Creates a window that cycles through a sequence of images.

WgSimageTool, image_data [, parent [, shell]]

Creates two windows: 1) a scrolling image window and 2) an optional smaller window that shows a reduced view of the entire image.

WgSliceTool, block_data [, parent [, last_slice [, shell]]]

Creates a window with a built-in set of controls; these controls allow you to easily select and view "slices" from a three-dimensional block of data.

WgStripTool [, x, y1, y2, ... , y10, parent [, shell]]

Creates a window that displays data in a style that simulates a real-time, moving strip chart.

WgSurfaceTool, surface_data [, parent [, shell]] 431

Creates a surface window with a built-in set of controls: these controls allow you to interactively modify surface parameters and view the result of those modifications.

WgTextTool [, parent [, shell]]

Creates a scrolling window for viewing text from a file or character string.

Concurrent Processing Routines

SELECT_READ_LUN, luns

Waits for input on any list of logical unit numbers.

EXEC_ON_SELECT, luns, commands

Registers callback procedures on input for a vector of logical unit numbers (LUNs).

ADD_EXEC_ON_SELECT, lun, command

Adds a single new item to the EXEC_ON_SELECT list.

DROP_EXEC_ON_SELECT, lun

Drops a single item from the EXEC_ON_SELECT list.

Procedure and Function Reference

This chapter contains detailed descriptions of the procedures and functions distributed with PV-WAVE. Most of these system procedures and functions are proprietary. However, you have access to the source code for some routines—such routines are called Standard Library procedures and functions.

Standard Library Routines

Standard Library procedures and functions are designated as such in their descriptions. The code for these routines can be found in `wave/lib/std`.

Users' Library Routines

Additional routines that have been contributed by PV-WAVE users comprise the Users' Library. For a list of such routines distributed with your version of PV-WAVE, see the `wave/lib/user` subdirectory.

Users' Library routines are not covered in this chapter; use the documentation available in the `.pro` source file for each routine in the `wave/lib/user` subdirectory.

For more information, see *The Users' Library* on page 255 of the *PV-WAVE Programmer's Guide.*

ABS Function

Returns the absolute value of x.

Usage

result = ABS(x)

Input Parameters

x – The value that is evaluated. May be of any dimension.

Returned Value

result – The absolute value of x.

Keywords

None.

Discussion

ABS is defined by:

$$f(x) = |x|$$

If x is an array, the result has the same dimension. Each element of the returned array contains the absolute value of the corresponding element in the input array.

When x is a complex number, the result is the magnitude of the complex number:

$$result_i = \sqrt{Real_i^2 + Imaginary_i^2}$$

When x has a data type of complex or string, the result is double-precision floating-point. All other data types produce a result with the same data type as x.

Examples

```
x = [-1, 2, 3, -4, 5]
PRINT, ABS(x)
   1    2    3    4    5

x = [4 + 3i]
PRINT, ABS(x)
   5.0
```

ACOS Function

Returns the arc-cosine of *x*.

Usage

result = ACOS(*x*)

Input Parameters

x – The cosine of the desired angle. Cannot be of a complex data type and must be in the range $-1 \leq x \leq 1$.

Returned Value

result – Arc-cosine of *x*.

Keywords

None.

Discussion

The inverse cosine function, or arc-cosine, denoted by cos^{-1}, is defined by:

$$y = cos^{-1}x$$

if and only if

$$\cos y = x$$

where

$$-1 \leq x \leq 1 \text{ and } 0 \leq y \leq \pi$$

The parameter *x* can be an array, with the result having the same data type where each element contains the arc-cosine of the corresponding element from *x*.

When *x* is of double-precision floating-point data type, the result is of the same type. All other data types are converted to single-precision floating-point and yield a floating-point result. The result is an angle, expressed in radians, whose cosine is *x*.

Values generated by ACOS range between 0 and π.

Example

```
x = ACOS(1)
PRINT, x
   0
```

See Also

COS

For a list of other transcendental functions, see *Transcendental Mathematical Functions* on page 20.

ADD_EXEC_ON_SELECT Procedure

Adds a single new item to the EXEC_ON_SELECT list.

Usage

ADD_EXEC_ON_SELECT, *lun*, *command*

Input Parameters

lun – Logical unit number.

command – Procedure name.

Description

A new logical unit number and associated command is added to the EXEC_ON_SELECT list. This procedure is designed to be called from an EXEC_ON_SELECT callback procedure.

See Also

SELECT_READ_LUN, EXEC_ON_SELECT, DROP_EXEC_ON_SELECT

ADDSYSVAR Procedure

Standard Library procedure that lets you define new system variables. Should only be used with Version 1 of PV-WAVE.

Usage

ADDSYSVAR, *name, type* [, *string_length*]

Input Parameters

name – The name of the system variable. Must be a scalar string starting with the ! character.

type – The type of the system variable expressed as a one-character string. The following are valid data type values:

Value	Description
B	Byte
D	Double-precision floating-point
F	Floating-point
I	Integer
L	Longword
S	String

string_length – Not used. (This parameter is present only for compatibility with Version 1 of PV-WAVE.)

Keywords

None.

Discussion

ADDSYSVAR lets you define constants or strings that will be used repeatedly as system variables, making them easily accessible. This procedure takes the name and initialized values and passes them directly to the DEFSYSV procedure.

The initialized values are set as zero for the appropriate type (i.e., 0.0 for floating-point or 0L for long integer); if the type is string, they are set as the null string (' '). The system variable will then need to be assigned to the appropriate value.

Note ADDSYSVAR is present for backward compatibility and should be used only with code taken from Version 1 of PV-WAVE. Users of more recent versions of PV-WAVE should use the DEFSYSV procedure instead.

Example

```
ADDSYSVAR, '!cm', 'f'
!cm = 2.54
inches = 20.3
value_in_cms = inches * !cm
PRINT, value_in_cms
   51.5620
```

See Also

DEFSYSV

For more information, see Chapter 4, *System Variables*.

ADJCT Procedure

Standard Library procedure that lets you interactively change the range and lower limit of the current color table.

Usage

ADJCT

Parameters

None.

Keywords

None.

Discussion

ADJCT works only on displays with window systems. It creates an interactive window that lets you use the mouse to change the range and lower limit of the current color table. This window is shown in Figure 2-1.

The ADJCT window contains the following items:

- **Color Bar** – Displays the current color table.
- **Graph** – Displays the color intensity versus pixel value.
- **Control Button Area** – Contains buttons for manipulating the display (labeled Ramp, Segments, and Draw) and for getting Help.

  To select a button, click on it with the left mouse button.

  Click the Help button to display information about using the other buttons.

To exit ADJCT, click the right mouse button.

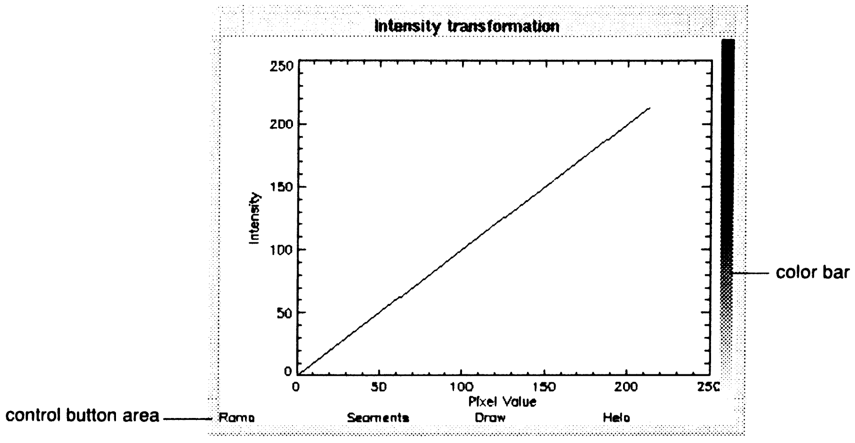


Figure 2-1 The ADJCT window lets you use the mouse to change the range and lower limit of the current color table.

Example

```
b = FINDGEN(200)
y = SIN(b/5)/EXP(b/50)
yy = y # y
LOADCT, 5
TVSCL, yy
ADJCT
```

— User modifies the color table and exitsthe procedure.
—

```
TVLCT, r, g, b, /Get
SAVE, Filename='test_colortable', r, g, b
LOADCT, 9
RESTORE, 'test_colortable'
TVLCT, r, g, b
```

See Also

C_EDIT, COLOR_EDIT, COLOR_PALETTE, HLS, HSV, LOADCT, MODIFYCT, PALETTE, PSEUDO, STRETCH, TVLCT, WgCbarTool, WgCeditTool, WgCtTool

For background information about color systems, see *Understanding Color Systems* on page 305 of the *PV-WAVE User's Guide.*

ALOG Function

Returns the natural logarithm of x.

Usage

result = ALOG(x)

Input Parameters

x — The expression that is evaluated. Must be > 0. Can be an array.

Returned Value

result — The natural logarithm of x.

Keywords

None.

Discussion

ALOG is defined as:

$$y = log_e x$$

Double-precision floating-point and complex values return a result with the same data type. All other types are converted to single-precision floating-point and yield a floating-point result.

ALOG handles complex numbers in the following way:

$$Alog(x) \equiv Complex(\log_e(|x|, \arctan(x)))$$

Examples

```
x = ALOG(10)
PRINT, x
   2.30259
x = ALOG(1)
PRINT, x
   0
```

See Also

ALOG10

For a list of other transcendental functions, see *Transcendental Mathematical Functions* on page 20.

ALOG10 Function

Returns the logarithm to the base 10 of *x*.

Usage

result = ALOG10(*x*)

Input Parameters

x – The expression that is evaluated. Must be > 0. Can be an array.

Returned Value

result – The base 10 logarithm for *x*.

Keywords

None.

Discussion

ALOG10 is defined by:

$$y = log_{10}x$$

Double-precision floating-point and complex values return a result with the same data type. All other types are converted to single-precision floating-point and yield a floating-point result.

ALOG10 handles complex numbers in the following way:

$$Alog10(x) = Complex(log_{10}(|x|, arctan(x)))$$

Examples

```
x = ALOG10(10)
PRINT, x
   1

x = ALOG10(100)
```

```
PRINT, x
   2

x = ALOG10(50)
PRINT, x
   1.69897
```

See Also

ALOG

For a list of other transcendental functions, see *Transcendental Mathematical Functions* on page 20.

ASIN Function

Returns the arcsine of *x*.

Usage

result = ASIN(*x*)

Input Parameters

x — The sine of the desired angle. Cannot be a complex data type and must be in the range of ($-1 \le x \le 1$).

Returned Value

result — The arcsine of *x*.

Keywords

None.

Discussion

The inverse sine function, or arcsine, denoted by sin^{-1}, is defined by:

$$y = sin^{-1}x$$

if and only if

$$sin\, y = x$$

where

$$-1 \leq x \leq 1 \text{ and } -\pi/2 \leq y \leq \pi/2$$

The parameter x can be an array, with the result having the same data type as x, where each element contains the arcsine of the corresponding element from x.

When x is of double-precision floating-point data type, the result is of the same type. All other data types are converted to single-precision floating-point and yield a floating-point result. The result is an angle, expressed in radians, whose sine is x.

Values generated by ASIN range between $-\pi/2$ and $\pi/2$.

Example

```
x = ASIN(0)
PRINT, x
   0
```

See Also

SIN

For a list of other transcendental functions, see *Transcendental Mathematical Functions* on page 20.

ASSOC Function

Associates an array structure with a file, allowing random access input and output.

Usage

result = ASSOC(*unit, array_structure* [, *offset*])

Input Parameters

unit — The PV-WAVE file unit to associate with *array_structure.*

array_structure — An expression that defines the data type and structure of the associated data.

offset — The offset in the file to the start of the data in the file. For stream files and RMS block mode files, this offset is given in bytes. For RMS record-oriented files, this offset is specified in records.

Tip Offset is useful for skipping past descriptive header blocks in files.

Returned Value

result — A variable that associates the array structure with the file.

Keywords

None.

Discussion

ASSOC provides a basic method of random access input/output in PV-WAVE. The associated variable (the one storing the association) is created by assigning the result of ASSOC to a variable. This variable provides a means for mapping a file into vectors or arrays of a specified type and size.

ASSOC does not work with UNIX FORTRAN binary files.

Example 1

Assume you have a binary file, `image_file.img`, with five 512-by-512 byte images and a 1024-byte header:

```
OPENR 1, 'image_file.img'
    Open the file.
aimage = ASSOC(1, BYTARR(512, 512), 1024)
image1 = aimage(0)
    Read the first image.
image5 = aimage(4)
    Read the fifth image.
TV, aimage(2)
    Display the third image.
fft_image = FFT(aimage (1), -1)
    Do an FFT function on the second image.
arow = ASSOC(1, BYTARR(512), 1024)
row100 = arow(99)
    Read the 100th row.
PLOT, arow(512)
    Plot the first row in the second image.
```

Example 2

For another example showing how to transfer data into an associated variable, see *How Data is Transferred into Associated Variables* on page 214 of the *PV-WAVE Programmer's Guide.*

See Also

OPENR, OPENW

For background information, see Chapter 10, *Programming with PV-WAVE*, in the *PV-WAVE Programmer's Guide.*

ATAN Function

Calculates the arctangent of the input variable(s).

Usage

result = ATAN(*x* [, *y*])

Input Parameters

x – The tangent of the desired angle.

y – The divisor of *x*.

Returned Value

result – The arctangent of *x* (or optionally of *x*/*y*).

Keywords

None.

Discussion

ATAN returns the radian angle whose tangent is *x*. If the optional parameter *y* is used, then ATAN returns the radian angle for the tangent of *x*/*y*. The parameters for the ATAN function are the exact reverse of the usual definition of tangent as *y*/*x*.

The range of ATAN is between $-\pi/2$ and $\pi/2$ when *x* is the only parameter, and $-\pi$ and π when the *y* parameter is specified.

An "arithmetic error" warning is displayed if $x=y=0$.

Example

```
x = [0.1, 0.2, 0.3]
PRINT, ATAN(x, x)
   0.785398 0.785398 0.785398
```

See Also

ACOS, ASIN, COS, SIN, TAN

For a list of other transcendental functions, see *Transcendental Mathematical Functions* on page 20.

AVG Function

Standard Library function that returns the average value of an array. Optionally, it can return the average value of one dimension of an array.

Usage

result = AVG(*array* [, *dim*])

Input Parameters

array — The array that is averaged. May be any type except string.

dim — The specific dimension of *array* that will be averaged. Must be a number that is in the range $0 \le dim < n$, where *n* is the number of dimensions in *array.*

Returned Value

result — The average value of *array.* If *dim* is not specified, *result* will be of floating-point type; otherwise, it will be of the same data type as *array.*

If *dim* is specified, *result* is an array containing the average values for all elements of the specified dimension.

Keywords

None.

Discussion

AVG is defined as:

$$f(x) = \frac{\sum_{x=1}^{n} x_n}{n}$$

The optional parameter *dim* allows you to find the average values for one dimension of *array* rather than the whole array. The first dimension in the array is denoted by 0, the second dimension by 1, and so on.

If the dimension you specify is not valid for *array*, the input array is returned as the result.

Example 1

```
array = INTARR(3, 4)
array(*, 0) = [5, 7, 9]
array(*, 1) = [2, 8, 5]
array(*, 2) = [3, 4, 8]
array(*, 3) = [3, 3, 3]
PRINT, AVG(array)
   5.00000
PRINT, AVG(array, 0)
   7     5     5     3
PRINT, AVG(array, 1)
   3     5     6
```

Example 2

When AVG is called with the dimension parameter, the result is an array with the dimensions of the input array, except for the dimension specified. In this case, each element of the result is the average of the corresponding vector in the input array. For example, if `Array` has dimensions of `(3,4,5)`, then the command

```
avg_dim = AVG(array, 1)
```

is equivalent to these PV-WAVE commands:

```
avg_dim = FLTARR(3, 5)
FOR j = 0,4 DO BEGIN
   FOR i = 0,2 DO BEGIN
   avg_dim(i,j) = TOTAL(array(i,*,j)) / 4.
   ENDFOR
ENDFOR
```

See Also

MAX, MEDIAN, MIN, SQRT, STDEV

AXIS Procedure

Draws an axis of the specified type and scale at a given position.

Usage

AXIS [[[, *x*], *y*], *z*]

Input Parameters

x, *y*, and *z* – Scalars giving the coordinates of the new AXIS.

Input Keywords

XAxis – Specifies how the X axis is to be drawn:

0 Draws an axis under the plot window, with the tick marks pointing up.

1 Draws an axis over the window, with tick marks pointing down.

YAxis – Specifies how the Y axis is to be drawn:

0 Draws a Y axis at the left of the plot window, with tick marks pointing to the right.

1 Draws a Y axis at the right of the plot window, with tick marks pointing to the left.

ZAxis — Specifies how the Z axis is to be drawn:

1 Lower-right

2 Lower-left

3 Upper-left

4 Upper-right

Additional plotting keywords are listed below. For a description of each keyword, see Chapter 3, *Graphics and Plotting Keywords.*

Channel	Thick	XTitle	YType
Charsize	Tickformat	XType	
Charthick	Ticklen		ZAxis
Clip	Title	YAxis	ZCharsize
Color		YCharsize	ZGridstyle
Data	XAxis	YGridstyle	ZMargin
Device	XCharsize	YMargin	ZMinor
Font	XGridstyle	YMinor	ZRange
Gridstyle	XMargin	YNozero	ZStyle
Noclip	XMinor	YRange	ZTickformat
Nodata	XRange	YStyle	ZTicklen
Noerase	XStyle	YTickformat	ZTickname
Normal	XTickformat	YTicklen	ZTicks
Position	XTicklen	YTickname	ZTickv
Save	XTickname	YTicks	ZTitle
Subtitle	XTicks	YTickv	ZValue
T3d	XTickv	YTitle	

Output Keywords

Save — Indicates that the scaling to and from data coordinates established by the call to AXIS is to be saved in the appropriate axis system variable, !X, !Y, or !Z. If not present, the scaling is not changed.

Discussion

If no coordinates are specified, the axis is drawn in its default position as given by the *XAxis*, *YAxis* or *ZAxis* keyword. When drawing an X axis, the X coordinate is ignored. Similarly, the *y* and *z* parameters are ignored when drawing their respective axes.

The new scale is saved for use by subsequent overplots if the *Save* keyword is present.

For more information and an illustration, see *Specifying the Location of the Plot* on page 85 of the *PV-WAVE User's Guide.*

Example

The following example shows how the AXIS procedure can be used with normal or polar plots to draw axes through the origin dividing the plot window into four quadrants:

```
theta = FINDGEN(361) * !Dtor
PLOT, /Polar, XStyle=4, YStyle=4, $
   Title='Nine-Leaved Rose', $
   5 * (COS(9 * theta), theta
```

Make a polar plot, suppressing the X and Y axes with the XStyle and YStyle keywords.

```
WAIT, 2
AXIS, 0, 0, XAxis=0, /Data
```

Draw an X axis through data Y coordinate of 0. Because the XAxis keyword has a value of 0, the tick marks point down.

```
WAIT, 2
AXIS, 0, 0, 0, YAxis=0, /Data
```

Similarly, draw the Y axis through data X coordinate of 0.

See Also

PLOT

For more information, see *Drawing Additional Axes on Plots* on page 87 of the *PV-WAVE User's Guide.*

BESELI Function

Calculates the Bessel I function for the input parameter.

Usage

result = BESELI(*x* [, *n*])

Input Parameters

x – The expression that is evaluated. Must be > 0.

n – The order to which the BESELI function is calculated. Must be ≥ 0. The default is 0.

Returned Value

result – The Bessel I function for *x*. Has the same dimensions as *x*.

Keywords

None.

Discussion

The Bessel I function is one of a mathematical series that arise in solving differential equations for systems with cylindrical symmetry. The Bessel series can be useful in communications and signal processing, since they give the relative amplitude of the spectral components of a frequency-modulated carrier wave.

The Bessel I function is similar to the Bessel J function, except that it is evaluated for imaginary parameters.

BESELI is a numerical approximation to the solution of the differential equation for an imaginary *x*:

$$x^2 * y'' + x * y' - (x^2 + n^2) * y = 0 n \geq 0$$

The BESELI function is a solution of the first kind of (modified) Bessel functions of order *n*. The general solution of the above differential equation using the BESELI function can be shown in the following three ways for arbitrary constants A and B:

```
y = A * BESELI(x, n) + B * BESELI(x, –n)
```

Solution for $n \neq 0, 1, 2, \ldots$

```
y = A * BESELI(x, n) + B * BESELK(x, n)
```

Solution for all n.

or

$$y = A \cdot BESELI(x, n) + B \cdot BESELI(x, n) \cdot \int \frac{dx}{x \cdot (BESELI(x, n))^2}$$

Solution for all n.

Note that BESELK may be generated from the BESELI function.

See Also

BESELJ, BESELY

For a synopsis of all the Bessel functions, see *Mathematical Handbook of Formulas and Tables*, by Murray R. Spiegel, McGraw-Hill Book Company, New York, 1968.

For sample usage of the Bessel functions in physics, see *Boundary Value Problems*, Second Edition, edited by David L. Powers, Academic Press, New York, 1979, pp. 213-216.

BESELJ Function

Calculates the Bessel J function for the input parameter.

Usage

result = BESELJ(*x* [, *n*])

Input Parameters

x — The expression that is evaluated. Must be > 0.

n — The order to which the BESELJ function is calculated. Must be ≥ 0. The default is 0.

Returned Value

result — The Bessel J function for *x*. It is floating-point, with the same dimensions as *x*.

Keywords

None.

Discussion

The Bessel J function is one of a mathematical series that arise in solving differential equations for systems with cylindrical symmetry. The Bessel series can be useful in communications and signal processing, since they give the relative amplitude of the spectral components of a frequency-modulated carrier wave.

Bessel J is a Bessel function of the first order, and has a finite limit as *x* approaches zero.

BESELJ is a numerical approximation to the solution of the differential equation for a real *x*:

$$x^2 * y'' + x * y' + (x^2 - n^2) * y = 0 n \geq 0$$

The BESELJ function is a solution of the first kind of Bessel functions of order *n*. The general solution of the above differential equation using the BESELJ function can be shown in the following three ways for arbitrary constants A and B:

```
y = A * BESELJ(x, n) + B * BESELJ(x, –n)
```
Solution for n $\neq$ 0, 1, 2, . . .

```
y = A * BESELJ(x, n) + B * BESELY(x, n)
```
Solution for all n.

or

$$y = A \cdot BESELJ(x,n) + B \cdot BESELJ(x,n) \cdot \int \frac{dx}{x \cdot (BESELJ(x,n))^2}$$

Solution for all n.

Note Under UNIX, BESELJ uses the `j0(3M)`, `j1(3M)`, and `jn(3M)` functions from the UNIX math library. For details about any of these functions, refer to its UNIX `man` page.

See Also

BESELI, BESELY

For a synopsis of all the Bessel functions, see *Mathematical Handbook of Formulas and Tables*, by Murray R. Spiegel, McGraw-Hill Book Company, New York, 1968.

For sample usage of the Bessel functions in physics, see *Boundary Value Problems*, Second Edition, edited by David L. Powers, Academic Press, New York, 1979, pp. 213-216.

BESELY Function

Calculates the Bessel Y function for the input parameter.

Usage

result = BESELY(*x* [, *n*])

Input Parameters

x — The expression that is evaluated. Must be > 0.

n — The order to which the BESELY function is calculated. Must be ≥ 0. The default is 0.

Returned Value

result — The Bessel Y function for *x*. Has the same dimensions as *x*.

Keywords

None.

Discussion

The Bessel Y function is one of a mathematical series that arise in solving differential equations for systems with cylindrical symmetry. The Bessel series can be useful in communications and signal processing, since they give the relative amplitude of the spectral components of a frequency-modulated carrier wave.

Bessel Y is a Bessel function of the second order. Unlike the Bessel J function, it has no finite limit as *x* approaches zero.

BESELY is a numerical approximation to the solution of the differential equation for a real *x*:

$$x^2 * y'' + x * y' + (x^2 - n^2) * y = 0 n \geq 0$$

The BESELY function is a solution of the second kind of Bessel functions of order *n*. The general solution of the above differential equation using the BESELJ function is as follows:

$$BESELY(x, n) = \frac{BESELJ(x, n)\cos(n\pi) - BESELJ(x, -n)}{\sin(n\pi)}$$

when $n \neq 0, 1, 2, \ldots$

and

$$BESELY(x, n) = lim(p \rightarrow n) \frac{BESELJ(x, p)\cos(p\pi) - BESELJ(x, -p)}{\sin(p\pi)}$$

when $n = 0, 1, 2, \ldots$

Note Under UNIX, BESELY uses the `j0(3M)`, `j1(3M)`, and `jn(3M)` functions from the UNIX math library. For details about any of these functions, refer to its UNIX `man` page.

See Also

BESELI, BESELJ

For a synopsis of all the Bessel functions, see *Mathematical Handbook of Formulas and Tables*, by Murray R. Spiegel, McGraw-Hill Book Company, New York, 1968.

For sample usage of the Bessel functions in physics, see *Boundary Value Problems*, Second Edition, edited by David L. Powers, Academic Press, New York, 1979, pp. 213-216.

BILINEAR Function

Standard Library function that creates an array containing values calculated using a bilinear interpolation to solve for requested points interior to an input grid specified by the input array.

Usage

result = BILINEAR(*array, x, y*)

Input Parameters

array — The array that is interpolated. Must be a two-dimensional floating-point array with dimensions (*n, m*).

x — A floating-point array containing the *x* subscripts of *array* (see Discussion below). Must satisfy the following conditions:

$0 \le min(x) < n$

$0 < max(x) \le n$

y — A floating-point array containing the *y* subscripts of *array* (see Discussion below). Must satisfy the following conditions:

$0 \le min(y) < m$

$0 < max(y) \le m$

Returned Value

result — A two-dimensional floating-point array (*n, m*) containing the results of the bilinear interpolation for the requested points.

If *x* is of dimension *i* and *y* is of dimension *j*, the result has dimensions *(i, j)*. In other words, both *x* and *y* will be converted to *(i, j)* dimensions. If you want the result to have dimensions *(i, j)*, then *x* can be either *FLTARR(i)* or *FLTARR(i, j)*. This is also true for *y*.

Keywords

None.

Discussion

Given a two-dimensional input array, BILINEAR uses the specified set of reference points to compute each element of an output array with a bilinear interpolation algorithm.

The array *x*/*y* contains the X/Y subscripts of the elements in *array* that are used for the interpolation:

- If *x* is a one-dimensional array, the same subscripts are used in each row of the output array.
- If *x* is a two-dimensional array, different X subscripts may be used on each row of the output array.
- If *y* is a one-dimensional array, the same subscripts are used in each column of the output array.
- If *y* is a two-dimensional array, different Y subscripts may be used on each column of the output array.

Note that specifying *x* and *y* as two-dimensional arrays allows you to independently define the X and Y location of each point to be interpolated from the original array.

Tip Using two-dimensional arrays for *x* and *y* with BILINEAR increases the speed of the algorithm. If *x* and *y* are one-dimensional, they are converted to two-dimensional arrays before they are returned by the function. This permits them to be reused in subsequent calls to BILINEAR, thereby saving time.

Conversely, BILINEAR can be time consuming for large, one-dimensional arrays.

Example 1

```
array = FLTARR(3,3)
array(1, 1) = 1
```

Create an array that is all zeros except for a center value of 1.

```
x = [.1, .2]
y = [.1, .4, .7, .9]
```

Find the values where x = .1, .2 and y = .1, .4, .7, .9, knowing that when x = 1 and y = 1, the value in the array is 1, but at all other points it is zero.

```
PRINT, BILINEAR(array, x, y)
   0.0100000    0.0200000
   0.0400000    0.0800000
   0.0700000    0.140000
   0.0900000    0.180000
```

Example 2

```
a = DIST(100)
original = SHIFT(SIN(a/5)/EXP(a/50),50,50)
```

Create original data.

```
LOADCT, 5
```

Load color table 5.

```
TVSCL, original
```

Display data.

```
b = FINDGEN(100)
```

Make an array of linear values from 0 to 99.

```
PLOT, b
```

Look at b.

```
x = b^2 / 100.0
```

Create exponentially "warped" arrays to be used for spacing on the X axis.

```
OPLOT, x
```

Look at x; it is non-linear.

```
y = x
```

Set y equal to x.

```
result = BILINEAR(original, x, y)
```

Perform bilinear interpolation from "original" to "result" based on the (non-linear) spacing characteristics of the indices in x and y.

```
ERASE
TVSCL, result
```

Note that the original data has been interpolated in the upper right corner of "result" due to the non-linearity of the X and Y axis arrays.

See Also

CONGRID, INTERPOL, SPLINE

BINDGEN Function

Returns a byte array with the specified dimensions, setting the contents of the result to increasing numbers starting at 0.

Usage

result = BINDGEN(*dim*$_1$ [, *dim*$_2$, ... , *dim*$_n$])

Input Parameters

dim$_i$ – The dimensions of the result array. May be any scalar expression. Up to eight dimensions can be specified.

Returned Value

result – An initialized byte array. If the resulting array is treated as a one-dimensional array, then its initialization is given by the following:

$$array\,(i) = \mathrm{BYTE}\,(i\ \mathrm{MOD}\ 256)$$

$$\text{for}\quad i = 0, 1, \ldots, \left(\prod_{j=1}^{n} \mathrm{D}_j - 1\right).$$

Keywords

None.

Discussion

Each element of the result array is set to the value of its one-dimensional subscript.

Example 1

```
a = BINDGEN(4, 2)
```
Create byte array.

```
INFO, a
A          BYTE       = Array(4, 2)

PRINT, a
 0    1    2    3
 4    5    6    7
```

See Also

BYTARR, BYTE, CINDGEN, DINDGEN, FINDGEN, INDGEN, LINDGEN, SINDGEN

BREAKPOINT Procedure

Lets you insert and remove breakpoints in programs for debugging.

Usage

BREAKPOINT, *file, line*

Input Parameters

file – The name of the source file in which to insert the breakpoint.

line – The line number at which the breakpoint is to occur.

Input Keywords

Clear – Removes the breakpoint specified by *file* and/or *line*. Note that *file* is an optional parameter when used with the *Clear* keyword.

Set – Sets a breakpoint in the specified *file* at the specified *line* number.

Discussion

A breakpoint causes program execution to stop after the designated statement is executed. Breakpoints are specified using the source file name and line number. You can insert breakpoints in programs without editing the source file.

Once a breakpoint has stopped execution, use `.CON` to continue execution.

Use `INFO, /Breakpoint` to display the breakpoint table, which gives the index, module, line number, and file location of each breakpoint.

Examples

To clear a breakpoint:

```
BREAKPOINT, /Clear, 3
```

Clear the breakpoint at line 3 in the current routine.

```
BREAKPOINT, /Clear, 'test.pro', 8
```

Clear the breakpoint corresponding to the statement in the file test.pro, line number 8.

To set a breakpoint at line 23, in the source file `xyz.pro`:

```
BREAKPOINT, 'xyz.pro', 23
```

or

```
BREAKPOINT, /Set, 'xyz.pro', 23
```

See Also

CHECK_MATH, INFO, ON_ERROR, STOP

For more information on the .CON executive command, see *Using .CON* on page 29 of the *PV-WAVE User's Guide.*

BUILD_TABLE Function

Creates a table from one or more vectors (one-dimensional arrays).

Usage

result = BUILD_TABLE(' *var*$_1$ [*alias*], ..., *var*$_n$ [*alias*] ')

Input Paramters

var$_i$ – A vector (one-dimensional array) variable. If additional vectors are specified, they must contain the same number of elements as *var*$_i$. The input variable(s) can be of any PV-WAVE data type.

alias – Specifies a new name for the table column. By default, the input variable's name is used.

Returned Value

result – A table containing *n* columns, where *n* is equal to the number of input variables.

Keywords

None.

Discussion

Once created, you can subset the table using the QUERY_TABLE function. Each vector must have the same number of elements. If not, an error message is displayed and the table is not created.

A table is built from vector (one-dimensional array) variables only. You cannot include expressions in the BUILD_TABLE function. For example, The following BUILD_TABLE call is *not* allowed:

```
result = BUILD_TABLE('EXT(0:5), COST(0:5)')
```

However, you can achieve the desired results by performing the array subsetting operations first, then using the resulting variables in BUILD_TABLE. For example:

```
EXT = EXT(0:5)
COST = COST(0:5)
result = BUILD_TABLE('EXT, COST')
```

In addition, you cannot include scalars or multidimensional-array variables in BUILD_TABLE.

Example 1

The following command creates a table consisting of eight columns of data. The columns are created from data read into PV-WAVE and placed into vector variables.

```
phone_data = BUILD_TABLE('DATE, TIME, ' + $
   'DUR, INIT, EXT, COST, AREA, NUMBER')
```

Here is a portion of the resulting table:

DATE	TIME	DUR	INIT	EXT	COST	AREA	NUMBER
901002	093200	21.40	TAC	311	5.78	215	2155554242
901002	094700	1.05	BWD	358	0	303	5553869
901002	094700	17.44	EBH	320	4.71	214	2145559893
901002	094800	16.23	TDW	289	0	303	5555836
901002	094800	1.31	RLD	248	.35	617	6175551999
901003	091500	2.53	DLH	332	.68	614	6145555553
901003	091600	2.33	JAT	000	0	303	555344
901003	091600	.35	CCW	418	.27	303	5555190
901003	091600	1.53	SRB	379	.41	212	2125556618

You can use the INFO command to view the new table structure, for example:

```
INFO, /structure, phone_data
** Structure TABLE_0, 8 tags, 40 length:
DATE                LONG        901002
TIME                LONG        93200
```

```
DUR                FLOAT      21.4000
INIT               STRING     'TAC'
EXT                LONG       311
COST               FLOAT      5.78000
AREA               LONG       215
NUMBER             STRING     2155554242
```

Note The */Structure* keyword is used because tables are represented in PV-WAVE as an array of structures. For more information on this, see Chapter 8, *Creating and Querying Tables*, in the *PV-WAVE User's Guide.*

The QUERY_TABLE function can be used to retrieve information from this table. For example:

```
res = QUERY_TABLE(phone_data, $
   ' * Where COST > 1.0')
```

This query produces a new table containing only the rows where the cost is greater than one dollar.

Example 2

This example demonstrates the use of the optional *alias* parameter. This parameter lets you specify new names for the columns of the table. By default, the names of the input variables are used as column names.

```
phone_data1 = BUILD_TABLE('DATE Call_Date,' +$
   TIME Call_Time, DUR Call_Length,' + $
   'INIT, EXT, COST Charge, AREA Area_Code,'+$
   'NUMBER Phone_Number')
```

The structure of this table reflects the new column names:

```
INFO, /structure, phone_data
** Structure TABLE_0, 8 tags, 40 length:
CALL_DATE          LONG       901002
CALL_TIME          LONG       93200
CALL_LENGTH        FLOAT      21.4000
INIT               STRING     'TAC'
EXT                LONG       311
```

```
CHARGE            FLOAT      5.78000
AREA_CODE         LONG       215
PHONE_NUMBER      STRING     2155554242
```

See Also

QUERY_TABLE, UNIQUE

For more information on BUILD_TABLE, see Chapter 8, *Creating and Querying Tables*, in the *PV-WAVE User's Guide*.

For information on reading data into PV-WAVE variables, see Chapter 8, *Working with Data Files*, in the *PV-WAVE Programmer's Guide*.

BYTARR Function

Returns a byte vector or array.

Usage

result = BYTARR(dim_1 [, dim_2, ... , dim_n])

Input Parameters

dim_i – The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result – A one-dimensional or multi-dimensional byte array.

Input Keywords

Nozero – Normally, BYTARR sets every element of the result to zero. If *Nozero* is nonzero, this zeroing is not performed, thereby causing BYTARR to execute faster.

Examples

```
a = BYTARR(5)
PRINT, a
   0   0   0   0   0
b = BYTARR(2, 3, 5, 7)
INFO, b
   B   BYTE   = ARRAY(2, 3, 5, 7)
```

See Also

BINDGEN, BYTE, BYTEORDER, BYTSCL, DBLARR, COMPLEXARR, FLTARR, INTARR, LONARR, MAKE_ARRAY, STRARR

BYTE Function

Converts an expression to byte data type.

Extracts data from an expression and places it in a byte scalar or array.

Usage

result = BYTE(*expr*)

This form is used to convert data.

result = BYTE(*expr, offset* [, dim_1, ... , dim_n])

This form is used to extract data.

Input Parameters

expr — The expression to be converted, or from which to extract data.

offset — (Used to extract data only.) The offset, in bytes, from the beginning of *expr* to where the extraction is to begin. If present, causes BYTE to extract data, not convert it.

dim_i — (Used to extract data only.) The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result — If converting, returns a copy of *expr* converted to byte data type. The result has the same size and structure (scalar or array) as *expr.*

If extracting, returns a copy of only part of *expr* — the part that is defined by the *offset* and *dim*ension parameters. The result has the size and structure of the specified *dim*ensions and is of byte data type. If no *dim*ensions are specified, the result is scalar.

Keywords

None.

Discussion – Conversion Usage

BYTE can be useful in a variety of applications – for example, in hexadecimal math, when you want to be certain that you are working with a byte value to ensure that any comparison you make is valid.

If *expr* is of type string, each character is converted to its ASCII value and placed into a vector. In other words, each vector element is the ASCII character code of the corresponding character in the string.

If *expr* is not of type string, then *expr* is converted to byte data type. The result is *expr* modulo 256.

Tip Use BYTSCL to convert *expr* to byte data type using scaling rather than modulo.

Caution If the values of *expr* are within the range of a long integer, but outside the range of the byte data type (0 to +255), a misleading result occurs, without an accompanying message. For example, `BYTE(256)` erroneously results in 0. If the values of *expr* are outside the range of a long integer data type, an error message may be displayed.

In addition, PV-WAVE does not check for overflow during conversion to byte data type. The values in *expr* are simply converted to long integers and the low 8 bits are extracted.

Example 1

```
a = BYTE('01abc')
INFO, a
   A   BYTE    = Array(5)
PRINT, a
   48   49   97   98   99
```

Example 2

```
a = BYTE(1.2)
PRINT, a
   1
```

Example 3

```
a = BYTE(-1)
PRINT, a
   255
```

The calculated result is 255 (bytes are modulo 256).

See Also

BINDGEN, BYTARR, BYTEORDER, BYTSCL, COMPLEX, DOUBLE, FIX, FLOAT, LONG

For more information on using this function to extract data, see *Extracting Fields* on page 37 of the *PV-WAVE Programmer's Guide.*

BYTEORDER Procedure

Converts integers between host and network byte ordering. Can also be used to swap the order of bytes within both short and long integers.

Usage

BYTEORDER, *variable*$_1$, ... , *variable*$_n$

Input Parameters

variable$_i$ – A variable (see Discussion below).

Output Parameters

variable$_i$ – A variable (see Discussion below).

Input Keywords

Htonl – Host to network, longwords.

Htons – Host to network, short integers.

Lswap – Longword swap. Always swaps the order of the bytes within each longword. For example, the four bytes within a longword are changed from (B_0,B_1,B_2,B_3), to (B_3, B_2,B_1, B_0).

Ntohl – Network to host, longwords.

Ntohs – Network to host, short integers.

Sswap – Short word swap. Always swaps the bytes within short integers. The even and odd numbered bytes are interchanged.

Discussion

BYTEORDER is most commonly used when dealing with binary data from non-native architectures that may have different byte ordering. An easier solution to use when reading or writing this sort of data is the XDR format, as explained in *External Data Rep-*

resentation (XDR) Files on page 205 of the *PV-WAVE Programmer's Guide.*

The size of the parameter, in bytes, must be evenly divisible by two for short integer swaps, and by four for long integer swaps. BYTEORDER operates on both scalars and arrays. The parameter must be a variable, not an expression or constant, and may not contain strings.

Note The contents of *variable$_i$* are overwritten by the result.

Network byte ordering is big endian. This means that multiple byte integers are transmitted beginning with the most significant byte.

Examples

```
a = '1234'X
```

Form a hexadecimal value that can be easily interpreted. Note that the hex value "12" is in the high-order byte, and "34" is in the low-order byte.

```
b = a
```

Remember that b will be overwritten by BYTEORDER.

```
BYTEORDER, b, /Sswap
PRINT, Format='(2Z9)', a, b
   1234      3412
```

The result shows that the high- and low-order bytes in b have been switched.

```
a = '12345678'XL
b = a
BYTEORDER, b, /Lswap
PRINT, Format='(2Z9)', a, b
   12345678     78563412
```

Bytes in b are swapped as expected, whereas in hexadecimal format, two digits represent a single byte.

See Also

BYTE

BYTSCL Function

Scales and converts an array to byte data type.

Usage

result = BYTSCL(*array*)

Input Parameters

array — The array to be scaled and converted to byte data type.

Returned Value

result — A copy of *array* whose values have been scaled and converted to bytes.

Input Keywords

Max — The maximum value of *array* elements to be considered. If *Max* is not specified, *array* is searched for its largest value.

Min — The minimum value of *array* elements to be considered. If *Min* is not specified, *array* is searched for its smallest value.

Top — The maximum value of the scaled result. If *Top* is not specified, 255 is used.

Discussion

BYTSCL can be used in a variety of applications — for example, to compress the gray levels in an image to suit the levels supported by the particular hardware you are using. It can also be used to increase or reduce the contrast of an image by expanding or restricting the number of gray levels used.

BYTSCL linearly scales all values of *array* that lie in the range ($Min \le x \le Max$) into the range ($0 \le x \le Top$). The result has the same number of dimensions as the original array.

If the values of *array* are outside this range (*Min* $\le x \le$ *Max*), BYTSCL maps all values of *array* < *Min* to zero, and maps all values of *array* > *Max* to *Top* (255 by default).

Example

To scale an array of floats to byte values, you might enter the following:

```
arr = FINDGEN(100)
byt = BYTSCL(arr, Max=50.0)
PRINT, SIZE(byt)
   1          100             1          100
PRINT, byt
   0    5   10   15   20   25   30   35   40   45   50
       56   61   66   71   76   81   86   91
   96 101 107 112 117 122 127 132 137 142 147
      152 158 163 168 173 178 183 188
   193 198 203 209 214 219 224 229 234 239 244
      249 255 255 255 255 255 255 255
   255 255 255 255 255 255 255 255 255 255 255
      255 255 255 255 255 255 255 255
   255 255 255 255 255 255 255 255 255 255 255
      255 255 255 255 255 255 255 255
   255 255 255 255 255
```

Example 2

This example uses the BYTSCL function to enhance the contrast of an image. The image is stored in a byte array, *b*. The argument

```
BYTSCL(b, Min = 50, Max = 70)
```

in the second call to the TV procedure scales the values of *b* so all bytes with a value less than or equal to 50 are set to 0, and all bytes with a value greater than or equal to 70 are set to 255. All bytes with a value between 50 and 70 are scaled to lie in the range $0 < x < 255$.

```
OPENR, unit, FILEPATH('whirlpool.img', $
   Subdir = 'data'), /Get_Lun
```

Open the file galaxy.dat for reading.

```
b = BYTARR(512,512)
```

Retrieve the first galaxy image, which is stored as a 256 by 256-byte array.

```
READU, unit, b
FREE_LUN, unit
!Order = 1
```

```
LOADCT, 3
WINDOW, 0, Xsize = 1024, Ysize = 512
```

Load the red temperature color table and create a window big enough for two images.

```
TV, b, 0
```

Display the image, without any contrast enhancement, at left side of window.

```
TV, BYTSCL(b, Min = 50, Max = 70), 1
```

Display the contrast enhanced image at right side of window.

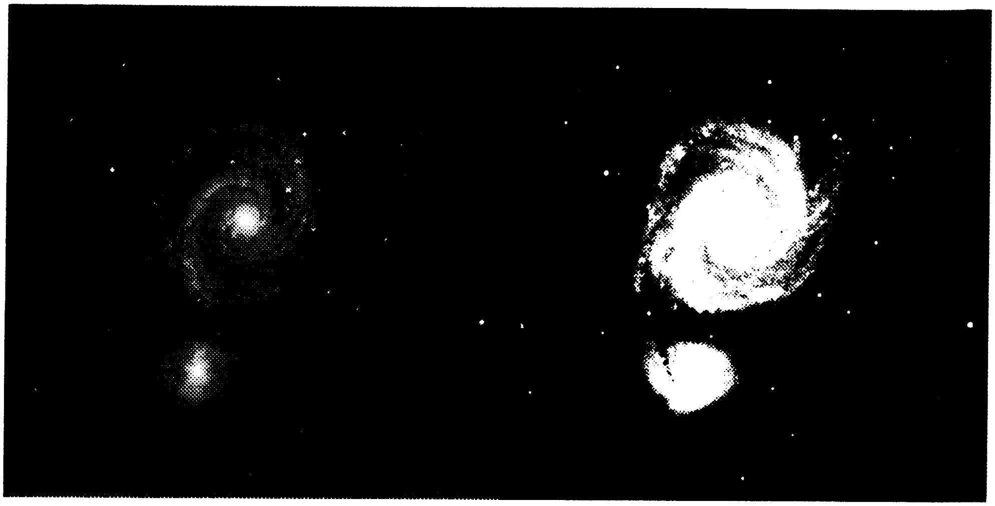


Figure 2-2 Galaxy image before (left) and after (right) contrast enhancement.

See Also

BYTE, BYTARR, BINDGEN

For more information on expressions, see *Type and Structure of Expressions* on page 34 of the *PV-WAVE Programmer's Guide.*

CALL_UNIX Function

(UNIX Only) Lets a PV-WAVE procedure communicate with an external routine written in C.

Usage

result = CALL_UNIX(p_1 [, p_2, ... , p_{30}])

Input Parameters

p_i – A variable of any type. At least one parameter must be passed, but can be up to 30. If the external routine does not require any parameters, the value of *p* must be zero.

Returned Value

result – A user-defined variable or data type to be returned from the external program. Cannot be –1, since –1 is reserved to indicate failure.

Input Keywords

Close – If present and nonzero, causes PV-WAVE to close *Unit* at the end of CALL_UNIX. (If *Unit* is not specified, *Close* has no effect.)

Hostname – A string that identifies the node name of the host on which the called external program is executing. If not specified, the default value of "localhost" is used.

Procedure – A string with a maximum length of 40 characters. Can say anything, but its intended use is to control program flow in the external routine.

Program – An integer identifier that enables the C routine `w_listen` to match a particular call to CALL_UNIX to a particular external routine. Must be greater than or equal to zero. The default value is zero. *Program* is intended to allow more than one external routine to be called by CALL_UNIX.

Unit – An integer used to reference an RPC socket:

- If *Unit* is zero, *Unit* is returned with a valid unit number.
- If *Unit* is nonzero, the value specified by *Unit* is used.
- If *Unit* is not specified, an RPC socket is reopened with each call to CALL_UNIX.

By specifying *Unit*, the overhead of opening an RPC socket each time is saved. In most cases, however, the overhead is not noticeable.

User – A string with a maximum length of 40 characters. Can say anything, but its intended use is for controlling access to the external routine.

Timeout – An integer that indicates the maximum time, in seconds, that PV-WAVE will wait for the external routine to finish. The default value is 60 seconds. If the external routine requires more than 60 seconds to execute, *Timeout* must be specified. There is no value to indicate an infinite amount of time.

Discussion

CALL_UNIX sends parameters to another process that is running the external C routine.

The external routine uses the following C routines:

- `w_listen` to connect with the process running PV-WAVE
- `w_get_par` to actually get the parameters
- `w_send_reply`, `w_smpl_reply`, or `w_cmpnd_reply` to send values and parameters back to PV-WAVE.

For information on these C routines, see Chapter 13, *Interapplication Communication*, in the *PV-WAVE Programmer's Guide*.

If an error occurs in a call to CALL_UNIX, –1 is returned. ON_IOERROR can also be used to catch CALL_UNIX errors.

Example

For examples, see Chapter 13, *Interapplication Communication*, in the *PV-WAVE Programmer's Guide*.

See Also

ON_IOERROR, UNIX_LISTEN, UNIX_REPLY

CD Procedure

Changes the current working directory.

Usage

CD [, *directory*]

Input Parameters

directory – If present, it should be a string specifying the path of the new working directory. If it is specified as a null string, the working directory is changed to the user's home directory.

Output Keywords

Current – Used to create a variable that stores the current directory name. You can store the name of the current working directory and change the working directory in a single statement:

```
CD, new_dir, Current=old_dir
```

The variable `old_dir` contains the name of the working directory before the change to `new_dir`.

Discussion

Initially, the working directory is the directory from which you started PV-WAVE.

This procedure changes the working directory for the current PV-WAVE session and any child processes started during the session after the change is made. It does not affect the working directory of the process that started PV-WAVE. Therefore, when you exit PV-WAVE, you will be in the directory you were in when you started.

The PUSHD, POPD, and PRINTD procedures, which maintain a directory stack and call CD to change directories, provide a convenient interface to CD.

Examples

On a UNIX system, to change the current working directory to `/usr/home/mydata`, enter:

```
WAVE> CD, '/usr/home/mydata'
```

On a VMS system, to change the current working directory to `SYS$SYSDEVICE:[MYDATA]`, enter:

```
WAVE> CD, 'SYS$SYSDEVICE:[MYDATA]'
```

On either system, to move to the home directory, enter:

```
WAVE> CD, ''
```

See Also

!Dir, !Path, FILEPATH, PUSHD, POPD, PRINTD

C_EDIT Procedure

Standard Library procedure that lets you interactively create a new color table based on the HLS or HSV color system.

Usage

C_EDIT [, *colors_out*]

Input Parameters

None.

Output Parameters

colors_out – Contains the color values of the final color table in the form of a two-dimensional array that has the number of colors in the color table as the first dimension and the integer 3 as the second dimension.

The values for red are stored in the first row, the values for green are stored in the second row, and those for blue in the third row; in other words:

red = colors_out(, 0)*
green = colors_out(, 1)*
blue = colors_out(, 2)*

Input Keywords

Hls – If set to 1, indicates the HLS (Hue, Lightness, Saturation) color system should be used.

Hsv – If set to 1, indicates the HSV (Hue, Saturation, Value) color system should be used. This is the default.

Discussion

C_EDIT works only on displays with window systems. It creates an interactive window that lets you use the mouse to create a new color table. This window is shown in Figure 2-3.

C_EDIT not only changes the colors displayed in the window that it creates, it also changes the colors in other windows so that you can watch different anomalies rise out of your data.

C_EDIT is similar to the COLOR_EDIT procedure, except that the color wheel has been replaced by two additional slider bars. This allows better control of HSV colors near zero percent saturation.

The C_EDIT window contains the following items:

- **Color Bar** — Displays the current color table. It is updated as changes are made to the color table. (When C_EDIT is initialized, it sets the current color table to red.)
- **Pixel Value Slider Bar** — Used to set tie points.
- **Color Parameter Slider Bars** — Used to adjust the values for the three color parameters of Value (or Lightness), Saturation, and Hue.
- **Graphs** — Plot the current values of the three color system parameters against pixel value. These graphs are updated as tie points are selected, and the color table is changed.

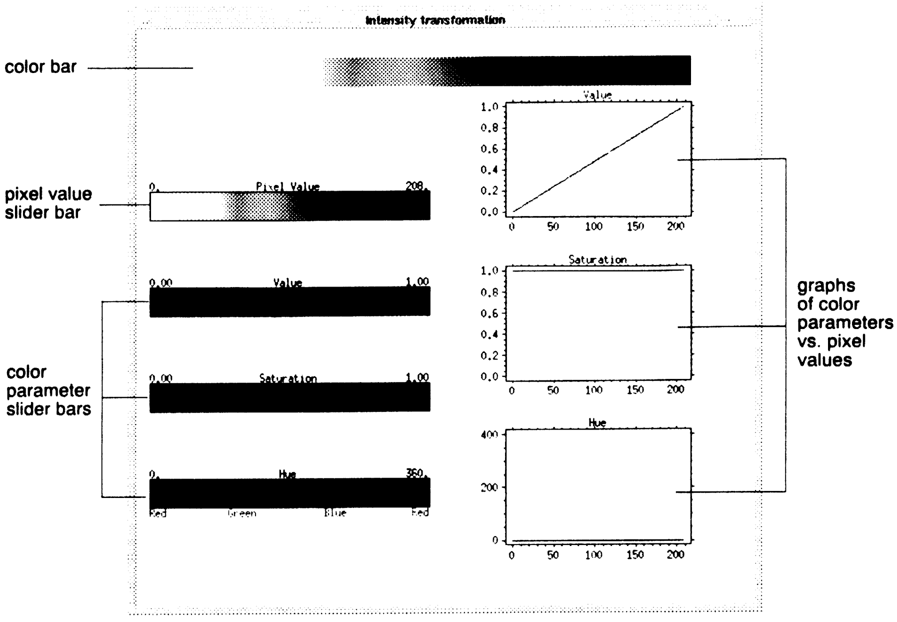


Figure 2-3 The C_EDIT window lets you use the mouse to create a new color table based on either the HLS or HSV color system.

To use C_EDIT:

- ❑ Adjust the three color-parameter slider bars by dragging the left mouse button within each bar until you reach the first color you want in your color table.
- ❑ On the pixel value slider bar, click with the left mouse button at the position where you want that particular color to be. (Note that the range on this bar begins at 0 and ends with the maximum value for your color table.)

  A small tie point then appears indicating the exact point where this color will occur in the color table. The values in the color table are interpolated between the tie points.
- ❑ If you need to erase the tie point, simply click on it with the middle mouse button.

Note that the color-system parameter graphs on the right of the window and the color bar at the top of the window are updated whenever a tie point is created or removed.

❑ Create your second color by again adjusting the three color-parameter slider bars and entering the corresponding tie point in the pixel value slider bar.

Repeat this step until you have finished creating all the colors you want in your color table.

❑ Use the right mouse button to exit the procedure.

Sample Usage

Assume that the HSV values associated with the default tie points are (0, 1, 0) for the 0 pixel value and (1, 1, 0) for the 255 pixel value. Suppose a new tie point at pixel value 100 is selected after setting the HSV values to (.8, .5, 0). Then the Hue values are interpolated between 0 and .8 and assigned to pixel values 0 to 100, and interpolated between .8 and 1 and assigned to pixel values 101 to 255. The Saturation values are interpolated between 1 and .5, and between .5 and 1, and assigned to the same pixel values. The Value quantities remain unchanged in this example.

You may select as many tie points as desired, with the understanding that each tie point is associated with the color system parameters in effect when the selection is made.

Note that when the HSV color system is being used, a Value of 1.0 is maximum brightness of the selected hue. In the HLS color system, a Lightness of 0.5 is the maximum brightness of a chromatic hue; 0.0 is black, and 1.0 is bright white. Also, in the HLS system, which models a double-ended cone, the Saturation has no effect at the extreme ends of the cone (i.e., Lightness equals 0 or 1).

Example 1

```
TVSCL, DIST(200)
C_EDIT, rgb_arry
```

— User modifies the color table and exits the procedure. —

```
SAVE, filename = 'my_colortable', rgb_array
LOADCT, 5
RESTORE, 'my_colortable'
rgb_array = REFORM(rgb_array, $
   N_ELEMENTS(rgb_array)/3,3)
TVLCT, rgb_array(*,0),rgb_array(*,1), $
   rgb_array(*,2)
```

Example 2

```
TVSCL, DIST(200)
C_EDIT
```

— User modifies the color table and exits the procedure. —

```
TVLCT, r, g, b, /get
SAVE, filename = 'my_colortable_ 2', r, g, b
LOADCT, 8
RESTORE, 'my_colortable_2'
TVLCT, r, g, b
```

See Also

ADJCT, COLOR_CONVERT, COLOR_EDIT, COLOR_PALETTE, HLS, HSV, LOADCT, MODIFYCT, PALETTE, PSEUDO, STRETCH, TVLCT, WgCbarTool, WgCeditTool, WgCtTool

For background information about color systems, see *Understanding Color Systems* on page 305 of the *PV-WAVE User's Guide.*

For an excellent discussion of the HSV and HLS color systems, see *Computer Graphics: Principles and Practice*, by Foley, Van Dam, Feiner, and Hughes, Second Edition, Addison Wesley Publishing Company, Reading, MA, 1990.

CENTER_VIEW Procedure

Sets system viewing parameters to display data in the center of the current window (a convenient way to set up a 3D view).

Usage

CENTER_VIEW

Parameters

None.

Input Keywords

Ax – The angle, in degrees, at which to rotate the data around the X axis. The default is –60.0.

Note The data is rotated *Az* degrees about the Z axis first, *Ay* degrees about the Y axis second, and *Ax* degrees about the X axis last.

Ay – The angle, in degrees, at which to rotate the data around the Y axis. The default is 0.0.

Az – The angle, in degrees, at which to rotate the data around the Z axis. The default is 30.0.

Persp – The perspective projection distance. If *Persp* is 0.0 (the default), then parallel projection is set.

Winx – The X size of the PV-WAVE plot window in device coordinates. The default is 640.

Winy – The Y size of the PV-WAVE plot window in device coordinates. The default is 512.

Xr, Yr, Zr – Two-element vectors. *Xr(0)*, *Yr(0)*, and *Zr(0)* contain the minimum X, Y, and Z values, respectively, in the data to be plotted. *Xr(1)*, *Yr(1)*, and *Zr(1)* contain the maximum values for this data. The default is [–1.0, 1.0] for each of *Xr, Yr*, and *Zr*.

Zoom – The magnification factor. The default is [0.5, 0.5, 0.5].

If *Zoom* contains one element, then the view is zoomed equally in the X, Y, and Z dimensions.

If *Zoom* contains three elements, then the view is scaled by *Zoom(0)* in the X direction, *Zoom(1)* in the Y direction, and *Zoom(2)* in the Z direction.

Discussion

CENTER_VIEW sets the system 3D viewing transformation and conversion factors from data coordinates to normal coordinates so that data is displayed in the center of the current window. The correct aspect ratio of the data is preserved even if the plot window is not square.

Note This procedure sets the system variables !P.T, !P.T3D, !X.S, !Y.S, and !Z.S, overriding any values you may have previously set. (These system variables are described in Chapter 4, *System Variables*.)

Examples

```
PRO f_gridemo4
```

This program shows 4D gridding of dense data and a cut-away view of a block of volume data.

```
points = RANDOMU(s, 4, 1000)
```

Generate random data to be used for shading.

```
ival = FAST_GRID4(points, 32, 32, 32)
ival = BYTSCL(ival)
```

Grid the generated data.

```
block = BYTARR(30, 30, 30)
block(*, *, *) = 255
block = VOL_PAD(block, 1)
```

Pad the data with zeroes.

```
block(0:16, 0:16, 16:31) = 0
```

Cut away a portion of the block array by setting the elements to zero.

```
WINDOW, 0, Colors=128
```

```
LOADCT, 3
CENTER_VIEW, Xr=[0.0, 31.0], Yr=[0.0, 31.0],$
   Zr=[0.0, 31.0], Ax=(-60.0), Az=45.0, $
   Zoom=0.6
```

Set up the viewing window and load the color table. (The indices for the 32-by-32-by-32 volume we are viewing go from 0 to 31.)

```
SET_SHADING, Light=[-1.0, 1.0, 0.2]
```

Change the direction of the light source for shading.

```
SHADE_VOLUME, block, 1, vertex_list, $
   polygon_list, Shades=ival, /Low
```

Compute the 3D contour surface.

```
img1 = POLYSHADE(vertex_list, polygon_list, $
   /T3d)
```

Render the cut-away block with light source shading.

```
img2 = POLYSHADE(vertex_list, polygon_list,$
   Shades=ival, /T3d)
```

Render the cut-away block shaded by the gridded data.

```
TVSCL, (FIX(img1) + FIX(img2))
```

Display the resulting composite image of the light source-shaded block and data-shaded image of the block.

```
END
```

For other examples, see the following demonstration programs in `$WAVE_DIR/demo/arl`: `grid_demo4`, `grid_demo5`, `sphere_demo1`, `sphere_demo2`, `sphere_demo3`, `vol_demo2`, `vol_demo3`, and `vol_demo4`.

See Also

SET_VIEW3D

CHEBYSHEV Function

Standard Library function that implements the forward and reverse Chebyshev polynomial expansion of a set of data.

Usage

result = CHEBYSHEV(*data, ntype*)

Input Parameters

data – The input data (either the original dataset or the Chebyshev polynomial expansion, depending upon *ntype).*

ntype – The numeric type to be returned:

–1 To return the set of Chebyshev polynomials.

+1 To return the original data.

Returned Value

result – The numeric type specified by *ntype*.

Keywords

None.

Discussion

CHEBYSHEV uses a straightforward implementation of the recursion formula. If you use discontinuous data, the result is subject to round-off error.

CHECK_MATH Function

Returns and clears the accumulated math error status.

Usage

result = CHECK_MATH([*print_flag, message_inhibit*])

Input Parameters

print_flag – If present and nonzero, indicates an error message is to be printed if any accumulated math errors exist. Otherwise, no messages are printed.

message_inhibit – Disables or enables the printing of math error exception error messages when they are detected. By default, these messages are enabled. Set *message_inhibit* to 1 to inhibit, and 0 to re-enable.

When the interpreter exits to the interactive mode, error messages are printed for accumulated math errors that were suppressed but not cleared.

Returned Value

result – An integer indicating the accumulated math error status since the last call or issuance of the interactive prompt. (See the Discussion section below for a list of values.)

Caution On machines that do not implement the IEEE standard for floating-point math, CHECK_MATH does not properly maintain an accumulated error status.

Input Keywords

Trap – Controls how floating-point traps are handled:

- If set to 0, no error messages are printed except the final accumulated error status.

- If set to 1 (the default), traps are enabled and programs are allowed to continue after floating-point errors. The first eight floating-point error exceptions issue error messages. Subsequent errors are silent.

  If a floating-point error occurs which is not logged, the accumulated floating-point error status is printed when PV-WAVE returns to the interactive mode.

Note Trap handling is machine dependent. Some machines won't work properly with traps enabled, while others don't allow disabling traps.

Discussion

The result of CHECK_MATH is 0 if no math errors have occurred since the last call or issuance of the interactive prompt. Other error status values as follows, where each binary bit represents an error:

Value	Condition
0	No errors detected since the last interactive prompt or call to CHECK_MATH.
1	Integer divide by zero.
2	Integer overflow.
16	Floating-point divide by zero.
32	Floating-point underflow.
64	Floating-point overflow.
128	Floating-point operand error. An illegal operand was encountered, such as a negative operand to the SQRT or ALOG functions; or an attempt to convert to integer a number whose absolute value is greater than $2^{31} - 1$.

Caution Not all machines detect all errors.

Example

```
a = [1.0, 1.0, 2.0]
```

Array a will not fail as divisor.

```
b = [1.0, 0.0, 2.0]
```

Second element should cause a divide-by-zero error.

```
junkstatus = CHECK_MATH(1, 0, Trap=1)
```

Clear previous error status and print error messages if an error exists.

```
c = 1.0 / a
status = CHECK_MATH(0, 0)
PRINT, a, c, status
   1.00000      1.00000      2.00000
   1.00000      1.00000     0.500000
         0
```

```
d = 1.0 / b
```

Cause an integer divide-by-zero error.

```
   % Program caused arithmetic error:
   % Floating divide by 0
   % Detected at $MAIN$ .
```

```
status = CHECK_MATH(0, 0)
PRINT, b, d, status
   1.00000      0.00000      2.00000
   1.00000          Inf     0.500000
        16
```

See Also

FINITE, ON_ERROR, RETURN, STOP

For additional information, see *Detection of Math Errors* on page 263 of the *PV-WAVE Programmer's Guide*. See also the section *Hardware-dependent Math Error Handling* on page 268 of the *PV-WAVE Programmer's Guide*.

CINDGEN Function

Returns a complex single-precision floating-point array.

Usage

result = CINDGEN(dim_1 [, dim_2, ... , dim_n])

Input Parameters

***dim**$_i$* – The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result – An initialized complex array with real and imaginary parts of type single precision, floating point. If the resulting array is treated as a one-dimensional array, then its initialization is given by the following:

$$array\ (i) = \mathrm{COMPLEX}\ (i, 0)$$

for $i = 0, 1, \ldots, \left(\prod_{j=1}^{n} \mathrm{D}_j - 1\right)$

Keywords

None.

Example

```
c = CINDGEN(4)
INFO, c
   C                COMPLEX   = Array(4)

PRINT, c
   (      0.00000,      0.00000)
   (      1.00000,      0.00000)
   (      2.00000,      0.00000)
   (      3.00000,      0.00000)
```

See Also

BINDGEN, COMPLEX, COMPLEXARR, DINDGEN, FINDGEN, INDGEN, LINDGEN, SINDGEN

CLOSE Procedure

Closes the specified file units.

Usage

CLOSE[, *unit*$_1$, ... , *unit*$_n$]

Input Parameters

unit$_i$ – The file units to close.

Input Keywords

All – If present and nonzero, closes all file units and frees any file units that were allocated via GET_LUN.

Files – If present and nonzero, closes all file units between 1 and 99. File units greater than 99, which are associated with the GET_LUN and FREE_LUN procedures, are not affected.

Discussion

All open files are closed and deallocated when you exit PV-WAVE.

Example

```
OPENW, 1, 'test'
PRINTF, 1, 'Example Text'
CLOSE, 1
```

See Also

GET_LUN, FREE_LUN, OPENR, OPENU, OPENW, READ, WRITEU

COLOR_CONVERT Procedure

Converts colors to and from the RGB color system and either the HLS or HSV systems.

Usage

COLOR_CONVERT, i_0, i_1, i_2, o_0, o_1, o_2, *keyword*

Input Parameters

i_0, i_1, i_2 – The input color triple(s). May be either scalars or arrays of the same length.

Output Parameters

o_0, o_1, o_2 – The variables to receive the result. Their structure is copied from the input parameters.

Input Keywords

One of the following *keywords* is required:

HLS_RGB – Convert from HLS (Hue, Lightness, Saturation) to RGB (Red, Green, Blue).

HSV_RGB – Convert from HSV (Hue, Saturation, Value) to RGB.

RGB_HLS – Convert from RGB to HLS.

RGB_HSV – Convert from RGB to HSV.

Discussion

RGB values are bytes in the range of 0 to 255.

Hue is a floating-point number measured in degrees, from 0.0 to 360.0; a Hue of 0.0 degrees is the color red, green is 120.0 degrees, and blue is 240.0 degrees.

Saturation, Lightness, and Value are floating-point numbers in the range of 0.0 to 1.0.

Note that when RGB values are the same during an RGB to HSV conversion, the Saturation is set to 0.0 and the Hue is undefined.

Example

```
COLOR_CONVERT, 255, 255, 0, h, s, v, /RGB_HSV
```

Converts the RGB color triple (`0,255,255`), which is the color yellow at full intensity and saturation, to the HSV system.

```
PRINT, h, s, v
    60.00000    1.00000    1.00000
```

The resulting Hue in the variable h is 60 degrees. The Saturation and Value (s and v) are set to 1.0.

See Also

COLOR_EDIT, HLS, HSV, HSV_TO_RGB, LOADCT, MODIFYCT, PALETTE, PSEUDO, RGB_TO_HSV, STRETCH, TVLCT, WgCeditTool

For background information about color systems, see *Understanding Color Systems* on page 305 of the *PV-WAVE User's Guide*.

For a discussion of the various color systems, see *Computer Graphics: Principles and Practice*, by Foley, Van Dam, Feiner, and Hughes, Second Edition, Addison Wesley Publishing Company, Reading, MA, 1990, pp. 585-596.

COLOR_EDIT Procedure

Standard Library procedure that lets you interactively create color tables based on the HLS or HSV color system.

Usage

COLOR_EDIT [, *colors_out*]

Input Parameters

None.

Output Parameters

colors_out – Contains the color values of the final color table in the form of a two-dimensional array that has the number of colors in the color table as the first dimension and the integer 3 as the second dimension.

The values for red are stored in the first row, the values for green are stored in the second row, and those for blue in the third row; in other words:

red = colors_out(, 0)*
green = colors_out(, 1)*
blue = colors_out(, 2)*

Input Keywords

HLS – If set to 1, indicates the HLS (Hue, Lightness, Saturation) color system should be used.

HSV – If set to 1, indicates the HSV (Hue, Saturation, Value) color system should be used. This is the default.

Discussion

COLOR_EDIT works only on displays with window systems. It creates an interactive window that lets you use the mouse to create a new color table. This window is shown in Figure 2-3.

COLOR_EDIT not only changes the colors displayed in the window that it creates, it also changes the colors in other windows so that you can watch different anomalies rise out of your data.

Tip If you need greater control of HSV colors near zero percent saturation, use the C_EDIT procedure.

The COLOR_EDIT window contains the following items:

- **Color Bar** – Displays the current color table. It is updated as changes are made to the color table. (When COLOR_EDIT is initialized, it sets the current color table to red.)
- **Color Wheel** – Lets you simultaneously select the hue (position from the azimuth of the wheel) and saturation (distance from the center of the wheel) with the cursor.
- **Slider Bars** – Use the top bar to select either the Value (HSV system) or the Lightness (HLS system) parameter, depending on the system in use. Use the bottom bar to select the pixel value that will become a tie point (explained below).
- **Graphs** – Plots the current values of the three color system parameters versus pixel value. These graphs are updated as tie points are selected and the color table is changed.

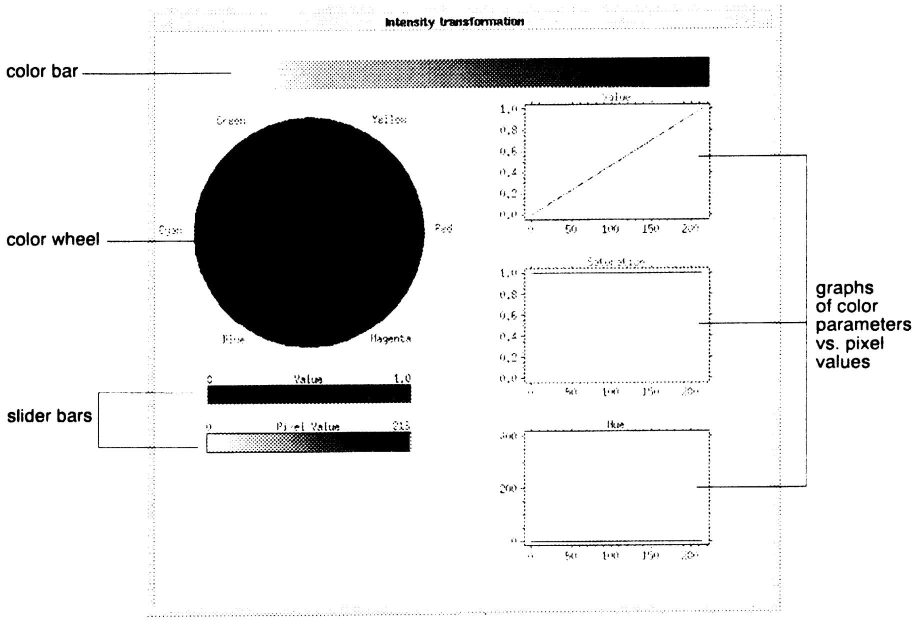


Figure 2-4 The COLOR_EDIT window lets you use the mouse to create a new color table based on either the HLS or HSV color system.

To use COLOR_EDIT:

❑ Adjust the value/lightness slider bar and color wheel by dragging the left mouse button within each until you reach the first color you want in your color table.

❑ On the pixel value slider bar, click with the left mouse button at the position where you want that particular color to be. (Note that the range on this bar begins at 0 and ends with the maximum value for your color table.)

A small *tie point* then appears indicating the exact point where this color will occur in the color table. The values in the color table are interpolated between the tie points.

❑ If you need to erase the tie point, simply click on it with the middle mouse button.

Note that the color system parameter graphs on the right of the window and the color bar at the top of the window are updated whenever a tie point is created or removed.

- ❑ Create your second color by again adjusting the value/lightness slider bar and color wheel and entering the corresponding tie point in the pixel value slider bar.

  Repeat this step until you have finished creating all the colors you want in your color table.

- ❑ Use the right mouse button to exit the procedure.

For more information on using interactive color table procedures, see *Sample Usage* on page 84.

Example 1

```
TVSCL, FINDGEN(256, 256)
COLOR_EDIT, rgb_array
```

— User modifies the color table and exits the procedure. —

```
SAVE, filename='my_colortable', rgb_array
LOADCT, 2
RESTORE, 'my_colortable'
rgb_array=REFORM(rgb_array, $
   N_ELEMENTS(rgb_array)/3, 3)
TVLCT, rgb_array(*, 0), rgb_array(*, 1), $
   rgb_array(*, 2)
```

Example 2

```
TVSCL, FINDGEN(256, 256)
COLOR_EDIT
```

— User modifies the color table and exits the procedure. —

```
TVLCT, r, g, b, /get
SAVE, filename='my_colortable_2', r, g, b
LOADCT, 8
RESTORE, 'my_colortable_2'
TVLCT, r, g, b
```

See Also

ADJCT, C_EDIT, COLOR_CONVERT, COLOR_PALETTE, HLS, HSV, LOADCT, MODIFYCT, PALETTE, PSEUDO, STRETCH, TVLCT, WgCbarTool, WgCeditTool, WgCtTool

For background information about color systems, see *Understanding Color Systems* on page 305 of the *PV-WAVE User's Guide.*

For an excellent discussion of the HSV and HLS color systems, see *Computer Graphics: Principles and Practice*, by Foley, Van Dam, Feiner, and Hughes, Second Edition, Addison Wesley Publishing Company, Reading, MA, 1990.

COLOR_PALETTE Procedure

Standard Library procedure that displays the current color table colors and their associated color table indices.

Usage

COLOR_PALETTE

Parameters

None.

Keywords

None.

Discussion

COLOR_PALETTE works only on displays with window systems. It displays the current color table in a new window, along with the corresponding numerical values or color table indices, thereby letting you visually determine the color associated with a particular color index. This window is shown in Figure 2-5.

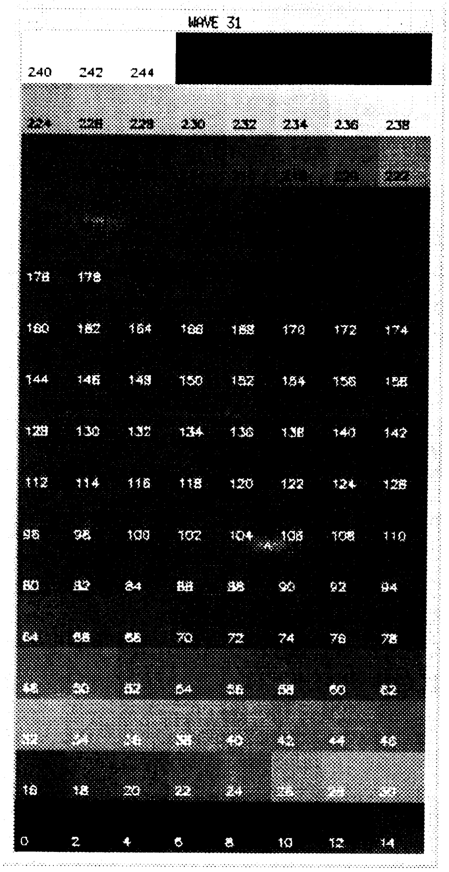


Figure 2-5 The COLOR_PALETTE window displays every other color in the current color table, along with the corresponding numerical value or color table index. The five black cells in the upper-right corner of the window represent colors that are not available to PV-WAVE because they have been reserved by some other application, such as the window manager.

Example 1

```
b = FINDGEN(37)
x = b * 10
y = SIN(x * !Dtor)
```

Create an array containing the values for a sine function from 0 to 360 degrees.

```
PLOT, x, y, XRange=[0,360], XStyle=1, YStyle=1
```

Plot data and set the range to be exactly 0 to 360.

```
COLOR_PALETTE
```

Put up a window containing a display of the current color table and its associated color indices.

```
TEK_COLOR
```

Load a predefined color table that contains 32 distinct colors.

```
POLYFILL, x, y, Color=6
POLYFILL, x, y/2, Color=3
POLYFILL, x, y/6, Color=4
```

Fill in areas under the curve with different colors.

```
z = COS(x * !Dtor)
```

Create an array containing the values for a COS function from 0 to 360 degrees.

```
OPLOT, x, z/8, Linestyle=2, Color=5
```

Plot the cosine data on top of the sine data.

Example 2

```
OPENR, lun, !Data_dir + 'head.img', /Get_lun
image = BYTARR(512, 512)
READU, lun, image
LOADCT, 0
TVSCL, image
COLOR_PALETTE
LOADCT, 5
LOADCT, 3
```

See Also

COLOR_CONVERT, COLOR_EDIT, MODIFYCT, PALETTE, WgCeditTool

For more information about the number of colors that are displayed in the palette, see *Determining the Number of Available Plot Colors* on page 322 of the *PV-WAVE User's Guide.*

COMPILE Procedure

Saves compiled user-written procedures and functions in a file.

Usage

COMPILE, *routine*$_1$ [, ..., *routine*$_n$]

Input Parameters

***routine*$_i$** – A string containing the name of the compiled function or procedure that you want to save.

Input Keywords

All – If nonzero, all currently compiled user-written functions and procedures are saved.

Filename – Specifies the name of a file in which to save specified compiled routines. By default, a file named *routine*`.cpr` is saved in the current working directory.

Verbose – If present and nonzero, prints a message for each saved function and procedure.

Discussion

The COMPILE procedure saves compiled routines in a format (XDR) that is recognized by all the platforms that support PV-WAVE.

When a compiled routine is called in a PV-WAVE application, the directories in the !Path system variable are searched for a `.cpr` file with the same name as the called routine. If the `.cpr` file is found, it is loaded and immediately executed. If a `.cpr` file is not found, PV-WAVE searches !Path for a `.pro` file with the same name. If the `.pro` file is found, it is executed instead.

Saved compiled routines can be executed directly from the operating system level. For example:

```
wave -r filename
```

The `-r` flag signifies "runtime" mode. It is possible to set an environment variable so that the `-r` flag is not needed. To do this on a UNIX system, enter:

```
setenv WAVE_FEATURE_TYPE RT
```

On a VMS system, enter:

```
DEFINE WAVE_FEATURE_TYPE RT
```

Then, you can execute compiled PV-WAVE routines from the operating system prompt by entering:

```
wave filename
```

Note that you do not use the `.cpr` extension when you execute compiled routines from the operating system prompt.

Example 1

This example demonstrates how to save a single compiled procedure. Assume the following procedure is saved in the current working directory in the file `log_plot.pro`:

```
PRO log_plot
   x = FLTARR(256)
   x(80:120) = 1
   freq = FINDGEN(256)
   freq = freq < (256-freq)
   fil = 1. / (1+(freq / 20) ^2)
   PLOT_IO, freq, ABS(FFT(X,1)), Xtitle = $
      'Relative Frequency', Ytitle ='Power', $
      Xstyle = 1
   OPLOT, freq, fil
   WAIT, 3
   WDELETE

END
```

Now start PV-WAVE, compile the procedure with .RUN, and save the compiled procedure in a file using the COMPILE procedure. Then, delete the compiled procedure from memory and run the compiled procedure that is stored in the file.

```
WAVE> .RUN log_plot
```

Compile the procedure.

```
WAVE> COMPILE, 'log_plot'
```

Save the compiled procedure.

```
WAVE> $ls log_plot*
log_plot.cpr   log_plot.pro
```

The file log_plot.cpr is created. This file contains the compiled procedure.

```
WAVE> DELPROC, 'log_plot'
```

Delete the log_plot procedure that is currently in memory.

```
WAVE> log_plot
```

Run the compiled procedure log_plot.cpr.

```
WAVE> EXIT
```

Exit PV-WAVE, and return to the operating system prompt.

```
% wave -r log_plot
```

Run the compiled procedure from the operating system prompt. The -r flag signifies "runtime" mode.

Example 2

This example demonstrates how several files from a single application can be compiled and saved in one file. This simple application creates a Command Tool widget and includes three separate callback routines.

Place the following code in a file called `comtool.pro`, and save the file in the current working directory:

```
;Widget commands

PRO ComTool
   top=WwInit('example2', 'Examples', layout)
   button=WwButtonBox(layout, 'Command', $
   'CbuttonCB')
   status=WwSetValue(top, /Display)
   WwLoop
END

;Callback routines

PRO CbuttonCB, wid, data
   command = WwCommand(wid, 'CommandOK', $
   'CommandDone', Position=[300,300], $
   Title = 'Command Entry Window')
END

PRO CommandOK, wid, shell
   value = WwGetValue(wid)
   PRINT, value
END

PRO CommandDone, wid, shell
   status = WwSetValue(shell, /Close)
END
```

Now start PV-WAVE and enter the following command:

```
WAVE> .RUN comtool
```

Compile the application.

```
WAVE> COMPILE, 'ComTool', 'CbuttonCB', $
    'CommandOK', 'CommandDone', $
    Filename = 'comtool'
```

Save the compiled procedures in the file comtool.cpr.

```
WAVE> $ls comtool*
comtool.cpr   comtool.pro
```

The file comtool.cpr is created. This file contains the compiled procedures.

```
WAVE> EXIT
```

```
% wave -r comtool
```

Run the compiled comtool application from the operating system command line. Note that the filename must be the same as the main procedure in the file for the application to run successfully from the operating system prompt. The -r flag signifies "runtime" mode.

See Also

SAVE, RESTORE

See also *Using PV-WAVE in Runtime Mode* on page 41 of the *PV-WAVE User's Guide* for more information.

COMPLEX Function

Converts an expression to complex data type.

Extracts data from an expression and places it in a complex scalar or array.

Usage

result = COMPLEX(*real* [, *imaginary*])

This form is used to convert data.

result = COMPLEX(*expr, offset,* dim_1 [, dim_2, ... , dim_n])

This form is used to extract data.

Input Parameters

real – (Used to convert data only). Scalar or array to be used as the real part of the complex result.

imaginary – (Used to convert data only.) Scalar or array to be used as the imaginary part of the complex result. If not present, the imaginary part of the result is zero.

expr – (Used to extract data only.) The expression to be converted, or from which to extract data.

offset – (Used to extract data only.) The offset, in bytes, from the beginning of *expr* to where the extraction is to begin.

dim_i – (Used to extract data only.) The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result – If converting, *result* is of type complex with the size and structure of *result* determined by the size and structure of *real* and *imaginary.* If either or both of the parameters are arrays, the result will be an array, following the same rules as standard PV-WAVE operators.

If extracting, *result* is of type complex with the size and structure of *result* determined by the *dimension* parameters.

Keywords

None.

Discussion – Conversion Usage

COMPLEX is used primarily to convert data to complex data type. If *real* is of type string and if the string does not contain a valid floating-point value (thereby making it impossible to convert), then PV-WAVE returns 0 and displays a notice. Otherwise, *expr* is converted to complex data type. The ON_IOERROR procedure can be used to establish a statement to be jumped to in the case of such errors.

If only one parameter is supplied, the imaginary part of the result is 0; otherwise, it is set by the *imaginary* parameter. Parameters are first converted to single-precision floating-point.

Note If three or more parameters are supplied, COMPLEX extracts fields of data from *expr*, rather than performing conversion.

Example

```
real = INDGEN(5)
b = COMPLEX(real)
INFO, b
   B               COMPLEX   = Array(5)
PRINT, b
   (      0.00000,      0.00000)
   (      1.00000,      0.00000)
   (      2.00000,      0.00000)
   (      3.00000,      0.00000)
   (      4.00000,      0.00000)
img = INTARR(5) + 6
c = COMPLEX(real, img)
INFO, c
```

```
   C                  COMPLEX    = Array(5)
PRINT, c
   (      0.00000,      6.00000)
   (      1.00000,      6.00000)
   (      2.00000,      6.00000)
   (      3.00000,      6.00000)
   (      4.00000,      6.00000)
d = COMPLEX(real, 7)
INFO, d
   D                  COMPLEX    = Array(5)
PRINT, d
   (      0.00000,      7.00000)
   (      1.00000,      7.00000)
   (      2.00000,      7.00000)
   (      3.00000,      7.00000)
   (      4.00000,      7.00000)
e = COMPLEX(7, img)
INFO, e
   E                  COMPLEX    = Array(5)
PRINT, e
   (      7.00000,      6.00000)
   (      7.00000,      6.00000)
   (      7.00000,      6.00000)
   (      7.00000,      6.00000)
   (      7.00000,      6.00000)
```

See Also

BYTE, COMPLEXARR, DOUBLE, FIX, FLOAT, LONG

For more information on using this function to extract data, see *Extracting Fields* on page 37 of the *PV‑WAVE Programmer's Guide.*

COMPLEXARR Function

Returns a complex single-precision floating-point vector or array.

Usage

result = COMPLEXARR(*dim*$_1$ [, *dim*$_2$, ... , *dim*$_n$])

Input Parameters

dim$_i$ – The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result — A complex single-precision floating-point vector or array.

Input Keywords

Nozero — Normally, COMPLEXARR sets every element of the result to zero. If *Nozero* is nonzero, this zeroing is not performed, thereby causing COMPLEXARR to execute faster.

Example

```
c = COMPLEXARR(4)
INFO, c
   C                COMPLEX   = Array(4)
PRINT, c
   (      0.00000,      0.00000)
   (      0.00000,      0.00000)
   (      0.00000,      0.00000)
   (      0.00000,      0.00000)
```

See Also

BYTARR, CINDGEN, DBLARR, FLTARR, INTARR, LONARR

CONE Function

Defines a conic object that can be used by the RENDER function.

Usage

result = CONE( )

Parameters

None.

Returned Value

result — A structure that defines a conic object.

Input Keywords

Color — A 256-element double-precision floating-point vector containing the color (intensity) coefficients of the object. The default is `Color(*)=1.0`. For more information, see the section *Defining Color and Shading* on page 198 of the *PV-WAVE User's Guide.*

Decal — A 2D array of bytes whose elements correspond to indices into the arrays of material properties. For more information, see the section *Decals* on page 201 of the *PV-WAVE User's Guide.*

Kamb — A 256-element double-precision floating-point vector containing the ambient (flat shaded) coefficients. The default is `Kamb(*)=0.0`. For more information, see the section *Ambient Component* on page 199 of the *PV-WAVE User's Guide.*

Kdiff — A 256-element double-precision floating-point vector containing the diffuse reflectance coefficients. The default is `Kdiff(*)=1.0`. For more information, see the section *Diffuse Component* on page 198 of the *PV-WAVE User's Guide.*

Ktran — A 256-element double-precision floating-point vector containing the specular transmission coefficients. The default is `Ktran(*)=0.0`. For more information, see the section *Transmission Component* on page 199 of the *PV-WAVE User's Guide.*

Radius — A double-precision floating-point number that corresponds to a scaling factor in the range [0...1]. *Radius* is multiplied by the upper radius at Z = +0.5 to give the lower radius at Z = –0.5. The default is `Radius=0.0`.

Transform — A 4-by-4 double-precision floating-point array containing the local transformation matrix whose default is the identity matrix. For more information, see the section *Setting Object and View Transformations* on page 201 of the *PV-WAVE User's Guide.*

Discussion

A CONE is used by the RENDER function to render conic objects, such as caps on axes. It is defined by default to be centered at the origin with a height of 1.0, and to have an upper radius of 0.5 (at Z = +1/2) and a lower radius of 0 (at Z = –1/2).

To change the upper radius, use the *Scale* keyword with the T3D procedure.

To change the lower radius, use the *Radius* keyword. For example, *Radius*=0.5 corresponds to a conic object whose lower radius is one-half of the upper radius, while *Radius*=0.0 corresponds to a point whose lower radius is 0 (a conic that ends in a point).

To change the dimensions and orientation of a CONE, use the *Transform* keyword.

Examples

```
T3D, /Reset, Rotate=[90, 0., 0]
c = CONE(Radius=0.33, Transform=!P.T)
TV, RENDER(c)
```

See Also

CYLINDER, MESH, RENDER, SPHERE, VOLUME

For more information, see *Ray-tracing Rendering* on page 196 of the *PV-WAVE User's Guide.*

CONGRID Function

Standard Library function that shrinks or expands an image or array.

Usage

result = CONGRID(*image, col, row*)

Input Parameters

image – The two-dimensional image to resample. Can be of any data type except string.

col – The number of columns to be in the resulting image.

row – The number of rows to be in the resulting image.

Returned Value

result – The resampled image or array.

Input Keywords

Interp – Specifies the interpolation method to be used in the resampling:

- If zero, uses the nearest neighbor method.
- If nonzero, uses the bilinear interpolation method.

Discussion

CONGRID shrinks or expands the number of elements in *image* by interpolating values at intervals where there might not have been values before. The resulting image is of the same data type as the input image.

The nearest neighbor interpolation method is not linear, because new values that are needed are merely set equal to the nearest existing value of *image*. Therefore, when increasing the image size, the result may appear as individual blocks. For more information, see *Efficiency and Accuracy of Interpolation* on page 170 of the *PV-WAVE User's Guide.*

Example 1

Here's what a mandril image looks like before and after using the following commands:

```
OPENR, lun, !Data_dir + 'mandril.img', $
   /Get_lun
mandril_img = BYTARR(512,512)
READU, lun, mandril_img
new_image = CONGRID(mandril_img, 400, 256)
TVSCL, mandril_img
ERASE
TVSCL, new_image
```

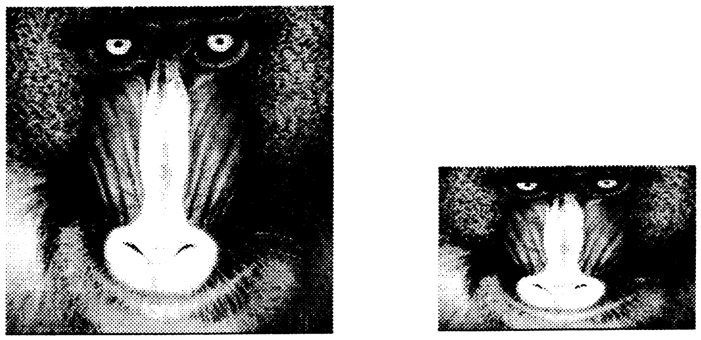


Figure 2-6 CONGRID has been used to shrink this 512-by-512 mandril image to one measuring 400-by-256.

Example 2

```
x = DIST(100)
new_x = CONGRID(x, 500, 200)
TVSCL, x
ERASE
TVSCL, new_x
```

See Also

REBIN, BILINEAR

CONJ Function

Returns the complex conjugate of the input variable.

Usage

result = CONJ(x)

Input Parameters

x — The variable that is evaluated. Can be a scalar or an array.

Returned Value

result — The complex conjugate of x.

Keywords

None.

Discussion

CONJ is defined as:

$$f(i, j) \equiv (i, -j)$$

where i represents the real part of x, and j represents the imaginary part of x.

If the input value x is not complex, then CONJ converts it to complex data type, with the real part described by x and the imaginary part set to 0.

If x is an array, the result has the same structure, with each element containing the complex conjugate of the corresponding element of x.

Example

```
p = COMPLEX(0, 1)
PRINT, p
   (   0.00000,      1.00000)
PRINT, CONJ(p)
   (   0.00000,     -1.00000)
```

See Also

COMPLEX, IMAGINARY

CONTOUR Procedure

Draws a contour plot from data stored in a rectangular array.

Usage

CONTOUR, *z* [, *x*, *y*]

Input Parameters

z — A two-dimensional array containing the values that make up the contour surface.

x — A vector or two-dimensional array specifying the *x* coordinates for the contour surface.

y — A vector or two-dimensional array specifying the Y coordinates for the contour surface.

Input Keywords

CONTOUR keywords are listed below. For a description of each keyword, see Chapter 3, *Graphics and Plotting Keywords.*

Background	Noclip	XStyle	YTitle
Channel	Nodata	XTickformat	YType
Charsize	Noerase	XTicklen	
Charthick	Normal	XTickname	ZAxis
Clip	Overplot	XTicks	ZCharsize
Color	Path_Filename	XTickv	ZGridstyle
C_Annotation	Position	XTitle	ZMargin
C_Charsize	Spline	XType	ZMinor
C_Colors	Subtitle		ZRange
C_Labels	T3d	YCharsize	ZStyle
C_Linestyle	Thick	YGridstyle	ZTickformat
C_Thick	Tickformat	YMargin	ZTicklen
Data	Ticklen	YMinor	ZTickname
Device	Title	YRange	ZTicks
Follow		YStyle	ZTickv
Font	XCharsize	YTickformat	ZTitle
Gridstyle	XGridstyle	YTicklen	ZValue
Levels	XMargin	YTickname	
Max_Value	XMinor	YTicks	
NLevels	XRange	YTickv	

Discussion

If *x* and *y* are provided, the contour is plotted as a function of the X,Y locations specified by their contents. Otherwise, the contour is generated as a function of the array index of each element of *z*.

If *x* is a vector, each element of *x* specifies the X coordinate for a column of *z*. For example, `X(0)` specifies the X coordinate for `Z(0, *)`. If *x* is a two-dimensional array, each element of *x* specifies the X coordinate of the corresponding point in *z* (x_{ij} specifies the X coordinate for z_{ij}).

If *y* is a vector, each element of *y* specifies the Y coordinate for a row of *z*. If *y* is a two-dimensional array, each element of *y* specifies the Y coordinate of the corresponding point in *z* (y_{ij} specifies the Y coordinate for z_{ij}).

CONTOUR draws contours using one of two different methods:

- The first method, used by default, examines each array cell and draws all contours emanating from that cell before proceeding to the next cell. This method is efficient in terms of computer resources, but does not allow contour labeling.
- The second method searches for each contour line and then follows the line until it reaches a boundary or closes. This method gives better-looking results with dashed line styles, and allows contour labeling, but requires more computer time. It is used if any of the following keywords is specified: *C_Annotation, C_Charsize, C_Labels, Follow, Spline,* or *Path_Filename.*

Although these two methods both draw correct contour maps, differences in their algorithms can cause small differences in the resulting graph.

Example

In the example below, a contour plot of random data is plotted. The random data is generated with the PV-WAVE Advantage RANDOMOPT procedure. The *Spline* keyword causes the contours to be smoothed using cubic splines. The vector assigned to the *Levels* keyword specifies the levels at which contours are desired. The vector of 1's assigned to the *C_Labels* keyword specifies that all contour levels should be labeled. The *C_Charsize* keyword is used to increase the size of the labels.

```
RANDOMOPT, Set = 1257
z = REFORM(RANDOM(36), 6, 6)
```

Create a 6 by 6 array of random numbers.

```
CONTOUR, z, /Spline, $
   Levels = [0.2, 0.4, 0.6, 0.8], $
   C_Labels = [1, 1, 1, 1], C_Charsize = 1.5
```

Create a contour plot from the random data.

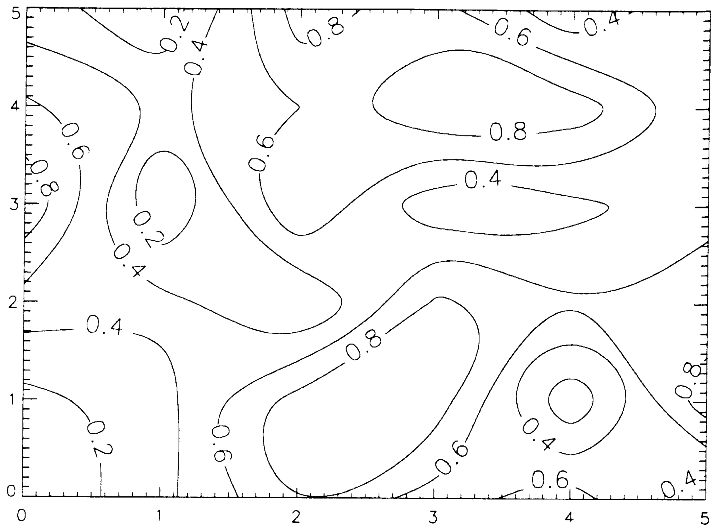


Figure 2-7 Contour plot of random data.

See Also

IMAGE_CONT, SURFACE, SHOW3

For more information, see Chapter 4, *Displaying 3D Data*, in the *PV-WAVE User's Guide.*

CONV_FROM_RECT Function

Converts rectangular coordinates (points) to polar, cylindrical, or one of two spherical coordinate systems: mathematical or global.

Usage

result = CONV_FROM_RECT(*vec1, vec2, vec3*)

Input Parameters

vec1 – A 1D array containing the X rectangular coordinates.

vec2 – A 1D array containing the Y rectangular coordinates.

vec3 – A 1D array containing the Z rectangular coordinates. For polar coordinates, set *vec3* to the scalar value 0.

Returned Value

result – By default, global spherical coordinates are returned with (0, *) containing the longitude, (1, *) containing the latitude, and (2, *) containing the radii. Note that latitude angles are given with respect to the horizontal axis or equator.

If the *Sphere* keyword is present and nonzero, mathematical spherical coordinates are returned as in the default case, except that the latitude angles are given with respect to the vertical, or polar, axis.

If the *Polar* keyword is present and nonzero, then a FLOAT(2, *n*) array is returned with (0, *) containing the angles and (1, *) containing the radii.

If the *Cylin* keyword is present and nonzero, then a FLOAT(3, *n*) array is returned with (0, *) containing the angles, (1, *) containing the radii, and (2, *) containing the Z values.

Input Keywords

Cylin — Specifies that cylindrical coordinates are to be returned.

Degrees — If present and nonzero, causes the returned coordinates to be in degrees instead of radians.

Global — If present and nonzero, the function returns global longitude and latitude angles. The longitude angles are the horizontal angles on the Earth's globe, where the angles east of the Greenwich meridian are positive, and angles to the west are negative. The latitude angles are vertical angles rotated with respect to the equator. They are positive in the northern hemisphere and negative in the southern hemisphere. By default, the function returns these global latitude and longitude values; this keyword can be used, however, to add clarity to the function call.

Polar — Specifies that polar coordinates are to be returned.

Sphere — If present and nonzero, the function returns a spherical coordinate system where the vertical angle is rotated with respect to the vertical (or polar) axis instead of the horizontal axis. The horizontal angles and radii are the same as in the global spherical case. This system is based on the set of conversion equations in the CRC Standard Mathematical Tables.

See Also

CONV_TO_RECT

For more information, see *Coordinate Conversion* on page 193 of the *PV‑WAVE User's Guide.*

CONVOL Function

Convolves an array with a kernel (or another array).

Usage

result = CONVOL(*array, kernel* [, *scale_factor*])

Input Parameters

array – The array to be convolved. Can be of any data type except string.

kernel – The array used to convolve each value in *array*. Must have dimensions smaller than those of *array*. Can be of any data type except string. (If a string array is used, PV-WAVE will attempt to convert it and then issue an error message.)

scale_factor – A scaling factor that reduces each output value by the specified factor (the default value is 1.0). Can be used with integer and byte type data only.

Returned Value

result – The convolved array. It is of the same data type and dimensions as *array*.

Input Keywords

Center – Specifies how the kernel is to be centered:

- If nonzero or omitted, centers the kernel over each array data point.
- If explicitly set to zero, centers the kernel in the strict mathematical sense.

Discussion

Convolution is a general process that can be used in smoothing, signal processing, shifting, edge detection, and other filtering functions. Therefore, it is often used in conjunction with other PV-WAVE functions, such as DIGITAL_FILTER, SMOOTH, and SHIFT.

Tip When using CONVOL with image data, make sure the data has been first converted to floating-point type.

The *kernel* is an array whose dimensions describe the size of the neighborhood surrounding the value in *array* that is analyzed. The *kernel* also includes values that give a weighting to each point in its array. These weightings determine the average that is the value in the output array. If *kernel* is not of the same type as *array*, a copy is made and converted into the same type before being used.

Using the *scale_factor* parameter allows you to simulate fractional kernel values and avoid overflow with byte parameters.

In many signal and image processing applications, it is useful to center a symmetric kernel over the data, thereby aligning the result with the original array. The *Center* keyword controls the alignment of the *kernel* with the *array* and the ordering of the kernel elements.

Sample Usage

In the convolution of any two functions, *r(t)* and *s(t)*, for most applications function *s* is typically a signal or data stream, which goes on indefinitely in time, while *r* is a response function, typically a peaked function that falls to zero in both directions from its maximum.

In terms of CONVOL parameters, *s* corresponds to *array* and *r* corresponds to *kernel*. The effect of convolution is to smear the signal *s(t)* in time according to the "recipe" provided by the response function *r(t)*.

One-Dimensional Convolution

For the example below, assume the following equation:

```
R = CONVOL(A, K, S)
```

where A is an n-element vector, K is an m-element vector ($m < n$), and S is the scale factor.

- If the *Center* keyword is set to 0, the results are as follows.

  When $t \geq m - 1$, then:

  $$R_t = (1/S)\sum_{i=0}^{m-1} A_{t-i} K_i$$

  Otherwise, $R_t = 0$.

- If the *Center* keyword is omitted or set to 1, the results are shown as follows.

  When $t \geq m - 1$, then:

  $$R_t = (1/S)\sum_{i=0}^{m-1} A_{t+i-m/2} K_i$$

  Otherwise, $R_t = 0$.

Two-Dimensional Convolution

For the second example, assume the same equation:

```
R = CONVOL(A, K, S)
```

where A is an *m-by-n* element array, K is an *l-by-l* element kernel, S is the scale factor, and the result R is an m-by-n element array.

- If the *Center* keyword is set to 0, the results are as follows.

  When $t \geq l - 1$ and $u \geq l - 1$, then:

  $$R_{t,u} = (1/S)\sum_{i=0}^{l-1}\sum_{j=0}^{l-1} A_{t-i,u-j} K_{i,j}$$

  Otherwise, $R_{t,u} = 0$.

- The centered two-dimensional case is similar, except the $t - i$ and $u - j$ subscripts are replaced by $t + i - l/2$ and $u + j - l/2$.

Example

Here is what a 512-by-512 mandril image looks like before and after applying the CONVOL function. For this example, the following parameters were used:

```
result = CONVOL(mandril_img, kernel, /Center)
```

where `kernel` is a 3-by-3 array with the following value:

$$\begin{bmatrix} -1 & 1 & 1 \\ -1 & -2 & 1 \\ -1 & 1 & 1 \end{bmatrix}$$

This kernel value represents a commonly-used algorithm for edge enhancement.

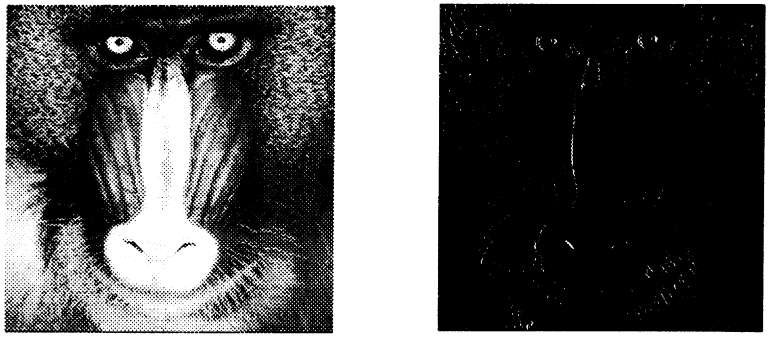


Figure 2-8 The CONVOL function has been used to enhance the edges of this 512-by-512 mandril image. In other words, after CONVOL is applied, the dark colors change quickly to light ones.

See Also

DIGITAL_FILTER, ROBERTS, SHIFT, SMOOTH, SOBEL

For more information on displaying images, see *Image Sharpening* on page 160 of the *PV-WAVE User's Guide* and *Image Smoothing* on page 158 of the *PV-WAVE User's Guide.*

For a signal processing example, see the DIGITAL_FILTERS *Example* section.

CONV_TO_RECT Function

Converts polar, cylindrical, or spherical (mathematical or global) coordinates to rectangular coordinates (points).

Usage

result = CONV_TO_RECT(*vec1*, *vec2*, *vec3*)

Input Parameters

vec1 – A 1D array containing the polar (longitude) angles.

vec2 – A 1D array containing the latitude angles, unless the *Polar* or *Cylin* keywords are present and nonzero. If either keyword is specified, then *vec2* should contain the radii.

vec3 – A 1D array containing the radii for spherical coordinates, unless *Polar* or *Cylin* keywords are present and nonzero. If *Polar* is specified, then *vec3* should be the scalar value 0 (it is ignored). If *Cylin* is specified, then *vec3* should contain the Z values.

Returned Value

result – If the *Polar* keyword is present and nonzero, then a FLOAT(2, *n*) array is returned with (0, *) containing the X coordinates and (1, *) containing the Y coordinates.

If *Polar* is zero (or not present), then a FLOAT(3, *) array is returned with (0, *) containing the X coordinates, (1, *) containing the Y coordinates, and (2, *) containing the Z coordinates.

Input Keywords

Cylin – Specifies that the input coordinates are cylindrical.

Degrees – If present and nonzero, causes the input coordinates to be in degrees instead of radians.

Global – If present and nonzero, causes the input coordinates to be in global longitude and latitude angles. The longitude angles are the horizontal angles on the Earth's globe, where the angles east of the Greenwich meridian are positive, and angles to the west are negative. The latitude angles are vertical angles rotated with respect to the equator. They are positive in the northern hemisphere and negative in the southern hemisphere. By default, the function expects these global latitude and longitude values; this keyword can be used, however, to add clarity to the function call.

Polar – Specifies that the input coordinates are polar.

Sphere – If present and nonzero, causes the input coordinates to be in a spherical coordinate system where the vertical angle is rotated with respect to the vertical (or polar) axis instead of the horizontal axis. The horizontal angles and radii are the same as in the global spherical case. This system is based on the set of conversion equations in the CRC Standard Mathematical Tables.

Examples

```
PRO vol_demo1
```

This program displays a 3D fluid flow vector field with random starting points for the vectors.

```
volx = 17
voly = 17
volz = 59
```

Specify the size of the volumes.

```
winx = 500
winy = 700
```

Specify the window size.

```
flow_axial = FLTARR(volx, voly, volz)
OPENR, 1, !Data_Dir + 'cfd_axial.dat', /Xdr
READU, 1, flow_axial
CLOSE, 1
flow_radial = FLTARR(volx, voly, volz)
OPENR, 1, !Data_Dir + 'cfd_radial.dat', /Xdr
READU, 1, flow_radial
```

```
CLOSE, 1
flow_tangent = FLTARR(volx, voly, volz)
OPENR, 1, !Data_Dir + 'cfd_tangent.dat', /Xdr
READU, 1, flow_tangent
CLOSE, 1
```

Read in the data as cylindrical coordinates.

```
flow_pressure = FLTARR(volx, voly, volz)
OPENR, 1, !Data_Dir + 'cfd_pressure.dat', /Xdr
READU, 1, flow_pressure
CLOSE, 1
```

Read in the data to be used for the vector color.

```
points = CONV_TO_RECT(flow_tangent(*), $
   flow_radial(*), flow_axial(*), /Cylin, $
   /Degrees)
```

Convert the data from cylindrical coordinates to Cartesian coordinates.

```
flow_x = FLTARR(volx, voly, volz)
flow_y = FLTARR(volx, voly, volz)
flow_z = FLTARR(volx, voly, volz)
flow_x(*) = points(0, *)
flow_y(*) = points(1, *)
flow_z(*) = points(2, *)
```

Split the points array into three 2D arrays to abstract the X, Y, Z values from the converted data.

```
T3D, /Reset
T3D, Translate=[-0.5, -0.5, -0.5]
T3D, Scale=[0.9, 0.9, 0.9]
T3D, Rotate=[0.0, 0.0, -30.0]
T3D, Rotate=[-60.0, 0.0, 0.0]
T3D, Translate=[0.5, 0.5, 0.5]
```

Set up the transformation matrix for the view.

```
WINDOW, 0, XSize=winx, YSize=winy, $
   XPos=256, YPos=128, Colors=128, $
   Title='3D Velocity Vector Field'
LOADCT, 4
```

Set up the viewing window and load the color table.

```
VECTOR_FIELD3, flow_x, flow_y, flow_z, 1000, $
   Max_Length=2.5, Vec_Color=flow_pressure, $
   Min_Color=32, Max_Color=127, $
   Axis_Color=100, Mark_Symbol=2, $
   Mark_Color=90, Mark_Size=0.5, Thick=2
```

Plot the converted data as a vector field.

```
END
```

For another example, see the `vec_demo2` demonstration program in `$WAVE_DIR/demo/arl`

See Also

CONV_FROM_RECT

For more information, see *Coordinate Conversion* on page 193 of the *PV-WAVE User's Guide.*

CORRELATE Function

Standard Library function that calculates a simple correlation coefficient for two arrays.

Usage

result = CORRELATE(*x*, *y*)

Input Parameters

x – The X array for which the correlation coefficient is calculated. Can be of any data type except string. Must be of the same data type and have the same number of elements as *y*.

y – The Y array for which the correlation coefficient is calculated. Can be of any data type except string. Must be of the same data type and have the same number of elements as *x*.

Returned Value

result – The simple product-moment correlation coefficient for *x* and *y*.

Keywords

None.

Discussion

CORRELATE calculates the product-moment correlation coefficient of the two arrays that are supplied.

Correlation can be characterized as the probability that values (i.e., the two input arrays) are related. In other words, it measures whether the events in one population are likely to have produced effects in another population. A result of 1.0 indicates a high correlation, while a result of 0.0 indicates no correlation whatsoever.

Example 1

```
scores_1 = [95,76,60,88,91,97,68,75,82,85]
scores_2 = [93,77,62,87,90,97,67,77,80,86]
scores_corr = CORRELATE(scores_1, scores_2)
PRINT, scores_corr
   .993408
```

Example 2

```
sample_1 = RANDOMU(seed, 128, 128)
sample_2 = RANDOMU(seed, 128, 128)
samples_corr = CORRELATE(sample_1, sample_2)
PRINT, samples_corr
   0.00
```

Example 3

```
x = DIST(200)
y = x
exact_corr = CORRELATE(x, y)
PRINT, exact_corr
   1.0000
```

COS Function

Calculates the cosine of the input variable.

Usage

result = COS(*x*)

Input Parameters

x — The angle for which the cosine is desired, specified in radians.

Returned Value

result — The trigonometric cosine of *x*.

Keywords

None.

Discussion

If *x* is of double-precision floating-point or complex data type, COS yields a result of the same type. All other types yield a single-precision floating-point result.

COS handles complex numbers in the following manner:

$$cos(x) = complex(cos(i)cosh(r), -sin(r)sinh(-i))$$

where *r* and *i* are the real and imaginary parts of *x*. If *x* is an array, the result of COS has the same dimensions (size and shape) as *x*, with each element containing the cosine of the corresponding element of *x*.

Example

```
x = [-60, -30, 0, 30, 60]
PRINT, COS(x * !Dtor)
   0.500000 0.866025 1.00000 0.866025
      0.500000
```

See Also

ACOS, ASIN, ATAN, COSH, COSINES, SIN, TAN

For a list of other transcendental functions, see *Transcendental Mathematical Functions* on page 20.

COSH Function

Calculates the hyperbolic cosine of the input variable.

Usage

result = COSH(*x*)

Input Parameters

x – The angle, in radians, that is evaluated.

Returned Value

result – The hyperbolic cosine of *x*.

Keywords

None.

Discussion

COSH is defined by:

$$cosh(x) \equiv (e^{x} + e^{-x})/2$$

If *x* is of double-precision floating-point data type, or of complex type, COSH yields a result of the same type. All other data types yield a single-precision floating-point result.

If *x* is an array, the result of COSH has the same dimensions, with each element containing the hyperbolic cosine of the corresponding element of *x*.

Example

```
x = [0.3, 0.5, 0.7, 0.9]
PRINT, COSH(x)
   1.04534     1.12763     1.25517     1.43309
```

See Also

COS, SINH, TANH

For a list of other transcendental functions, see *Transcendental Mathematical Functions* on page 20.

COSINES Function

Standard Library basis function that can be used by the SVDFIT function.

Usage

result = COSINES(*x*, *m*)

Input Parameters

x — A vector of data values with *n* elements.

m — The number of terms in the basis function.

Returned Value

result — An *n*-by-*m* array, such that:

```
result(i, j) = COS(j * x(i))
```

Keywords

None.

Discussion

COSINES consists simply of the following two lines:

```
FUNCTION COSINES, x, m
RETURN, COS(x # FINDGEN(m))
```

See Also

SVDFIT

CREATE_ HOLIDAYS Procedure

Standard Library procedure that creates the system variable !Holiday_List, which is used in calculating Date/Time compression.

Usage

CREATE_HOLIDAYS, *dt_list*

Input Parameters

dt_list – A Date/Time variable containing one or more days to be specified as holidays.

Keywords

None.

Discussion

The result is stored in the system variable !Holiday_List, a 50-element Date/Time array. !Holiday_List is used in calculating Date/Time compressions for functions that take the *Compress* keyword. For instance, the functions DT_SUBTRACT, DT_ADD, and DT_DURATION can take the *Compress* keyword which, if set, will exclude holidays from their results. In addition, the PLOT procedure uses the *Compress* keyword to exclude holidays from a plot.

Example1

The following commands define !Holiday_List to contain the dates for Christmas and New Years:

```
holidays=STR_TO_DT(['12-25-92', '1-1-92'],$
   date_fmt=1)

CREATE_HOLIDAYS, holidays
```

Example 2

```
CREATE_HOLIDAYS, STR_TO_DT('04-july-1992',$
   Date_Fmt=4)
```

See Also

CREATE_WEEKENDS, LOAD_HOLIDAYS, DT_COMPRESS, STR_TO_DT

CREATE_WEEKENDS Procedure

Standard Library procedure that creates the system variable !Weekend_List, which is used in calculating Date/Time compression.

Usage

CREATE_WEEKENDS, *day_names*

Input Parameters

day_names – A string or string array containing the weekend names.

Keywords

None.

Discussion

The result is stored in the system variable !Weekend_List, a seven-element integer array. The values in !Weekend_List are either ones or zeros, where 1 represents a weekend and 0 represents a weekday. The first element of !Weekend_List represents Sunday, and the last represents Saturday. !Weekend_List is used in calculating Date/Time compressions for functions that take the *Compress* keyword.

For instance, the routines DT_SUBTRACT, DT_ADD and DT_DURATION, can use the *Compress* keyword which, if set, excludes weekends from their results. In addition, the PLOT procedure uses the *Compress* keyword to remove weekends from a plot.

The values in the input string *day_names* must match or be a substring of strings in the !Day_Names system variable. By default, !Day_Names contains:

```
PRINT, !Day_Names
   Sunday Monday Tuesday Wednesday Thursday
   Friday Saturday
```

Thus `day_names = ['Sat', 'Sun']` is a valid assignment. If all days of the week are set to weekends, an error results.

Example 1

```
CREATE_WEEKENDS, 'Sat'
```
CREATE_WEEKENDS defines Saturday as a weekend.

```
PRINT, !Weekend_List
   0    0    0    0    0    0    1
```
The first element in the array !Weekend_List represents Sunday. The last represents Saturday. Weekend days have a value of 1.

See Also

DT_COMPRESS, CREATE_HOLIDAYS, LOAD_WEEKENDS

CROSSP Function

Standard Library function that returns the cross product of two three-element vectors.

Usage

result = CROSSP(v_1, v_2)

Input Parameters

v_1 — The first operand of the cross product. Must be a three-element vector.

v_2 — The second operand of the cross product. Must be a three-element vector.

Returned Value

result — A three-element floating-point vector containing the cross product of v_1 and v_2.

Keywords

None.

Discussion

The cross product of two arrays is commonly used in a variety of applications. It is defined as:

$$v_1 \times v_2 = \begin{bmatrix} i & j & k \\ a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \end{bmatrix}$$

or

$$v_1 \times v_2 = (b_1 c_2 - b_2 c_1) i - (c_1 a_2 - c_2 a_1) j + (a_1 b_2 - a_2 b_1) k$$

Example

```
v1 = [2, 1, -2]
v2 = [4, -1, 3]
result = CROSSP(v1, v2)
PRINT, result
   1   -14   -6
```

CURSOR Procedure

Reads the position of the interactive graphics cursor from the current graphics device.

Usage

CURSOR, *x*, *y* [, *wait*]

Input Parameters

wait – An integer specifying when CURSOR returns. This parameter may be used interchangeably with the keywords listed below that specify the type of wait.

Value	Keyword	Action
0	*Nowait*	Return immediately.
1	*Wait*	Return if button pressed (the default value).
2	*Change*	Return if button pressed, changed, or pointer moved.
3	*Down*	Return when button down transition is detected.
4	*Up*	Return when button up transition is detected.

Note Not all modes of waiting work with all display devices. Many devices, such as Tektronix terminals, do not have the ability to return immediately, and so always wait. In addition, not all types of waiting are available for devices that do not have the ability to sense transitions or states.

For device-specific information, see Appendix A, *Output Devices and Window Systems*, in the *PV-WAVE User's Guide.*

Output Parameters

x – A named variable to receive the cursor's current column.

y – A named variable to receive the cursor's current row.

Input Keywords

Change – Waits for pointer movement or button down within the currently selected window.

Data – If present and nonzero, causes the values placed into *x* and *y* to be in data coordinates (the default).

Device – If present and nonzero, causes the values placed into *x* and *y* to be in device coordinates.

Down – Waits for a button down transition within the currently selected window.

Normal – If present and nonzero, causes the values placed into *x* and *y* to be in normalized coordinates.

Nowait – Reads the pointer position and button status and return immediately. If the pointer is not within the currently selected window, the device coordinates –1, –1 are returned.

Up – Waits for a button up transition within the current window.

Wait – Waits for a button to be depressed within the currently selected window. If a button is already pressed, returns immediately.

Discussion

CURSOR enables the graphic cursor on the device and waits for the operator to position it. On devices that have a mouse, CURSOR normally waits until a mouse button is pressed. If no mouse is present, CURSOR waits for a key on the keyboard to be pressed.

Note Not all graphics devices have interactive cursors.

The system variable !Err is set to the button status; if no mouse is present, it is set to the ASCII code of the key. Each mouse button is assigned a bit in !Err – bit 0 is the left-most button, bit 1 the next, and so on.

Thus, for a three-button mouse, !Err will contain the values 1 – 7, depending upon which button or combination of buttons was pushed. For example, the left button produces a value of 1, the middle button 2, and the right button 4, while pressing the left and right buttons together produce the value 5.

The system variable !Mouse contains the X and Y position of the mouse, the mouse button status, and a date/time stamp. The mouse position is given in device coordinates. The button status appears as 1 – 7; these values are contained in the !Err system variable. The date/time stamp may not be available on all systems.

Since the values returned are, by default, in data coordinates, if no data coordinate system has been previously established, then calling CURSOR without specifying either the *Normal* or *Device* keywords will result in an error and procedural execution will be halted.

Example 1

```
WINDOW, XSize=512, YSize=512
CURSOR, x, y, /Normal
```

This returns the normalized coordinates of the point selected in the graphics window when a button is pressed. The button press is the default event activation, and not overtly specified.

Example 2: Using PLOTS Interactively

In this example, PLOTS and CURSOR are used in a loop to build a simple sketch pad. While the cursor is in the graphics window and a button is held down, CURSOR returns the device coordinates of the cursor. Procedure PLOTS draws a line segment between the previously returned cursor position and the current cursor position.

```
PRO sketch
false = 0
true = 1
window, 0

XYOUTS, 2, 2, "QUIT", Size = 2, /Device
```

Create a quit button in the window.

```
PLOTS, [0, 48, 48], [20, 20, 0], /Device
first = true

REPEAT BEGIN

   CURSOR, xnew, ynew, /Device
```

Get cursor position, placing the x-coordinate in xnew, and the y-coordinate in ynew.

```
   IF (xnew LE 48) AND (ynew LE 20) THEN STOP
```

If cursor position is within quit button, then stop.

```
   IF first THEN BEGIN
      xold = xnew
      yold = ynew
      first = false
   ENDIF
```

First time through loop, set xold and yold to be the same as xnew and ynew.

```
   PLOTS, [xold, xnew], [yold, ynew], /Device
```

Plot a line segment from (xold, yold) to (xnew, ynew).

```
   xold = xnew
   yold = ynew
```

```
ENDREP UNTIL FALSE
END
```

See Also

!Mouse, !Err, TVCRS

CURVEFIT Function

Standard Library function that performs a nonlinear least-squares fit to a function of an arbitrary number of parameters.

Usage

result = CURVEFIT(*x, y, wt, parms,* [*sigma*])

Input Parameters

x — A vector containing the X (independent) coordinates of the input data points. There are *n* elements in the vector.

y — A vector containing the Y (dependent) coordinates of the input data points. Must have the same number of elements as *x*.

wt — The vector of weighting factors for determining the weighting of the least-squares fit (see Discussion below). Must be the same size as *x*.

parms — A six-element vector containing the parameters of the fitted function. On input, it should contain the initial estimates of each parameter.

Output Parameters

parms — On output, contains the calculated parameters of the fitted function.

If *parms* is supplied as a double-precision variable, the calculations are performed in double-precision accuracy. Otherwise, the calculations are performed in single-precision accuracy.

sigma — A vector containing the standard deviations for the parameters in *parms*.

Returned Value

result — A vector containing the calculated Y coordinates of the fitted function.

Keywords

None.

Discussion

CURVEFIT uses a nonlinear least-squares method to fit an arbitrary function in which the partial derivatives are known or can be approximated. This is in contrast to linear least-squares fitting methods that would require their fitting functions to be linear in their coefficients.

The initial estimates of *parms* should be as close to the actual values as possible or the solution may not converge. CURVEFIT performs iterations of the fitting function until the chi-squared value for the goodness of fit changes by less than 0.1 percent, or until 20 iterations are reached.

Tip These initial estimates for *parms* can be calculated from the result of the POLY_FIT function when it is used to fit a straight line through data.

The function to be fit must be defined and called with the FUNCT procedure.

CURVEFIT is modified from the program CURFIT found in *Data Reduction and Error Analysis for the Physical Sciences,* by Philip Bevington, McGraw-Hill, New York, 1969. It combines a gradient search with an analytical solution developed from linearizing the fitting function. This method is termed a "gradient-expansion algorithm."

Weighting Factor

Weighting is useful when you want to correct for potential errors in the data you are fitting to a curve. The weighting factor, *wt*, adjusts the parameters of the curve so that the error at each point of the curve is minimized.

wt can have any value, as long as its size is correct. Some possible ways to weight a curve are suggested below (where *i* is an index into *y*, the vector of Y values):

- ✔ For statistical weighting, use $wt = 1/y_i$
- ✔ For instrumental weighting, use $wt = 1/(Std\ dev\ of\ y_i)$
- ✔ For no weighting, use $wt = 1$

- **Statistical Weighting** – Statistical weighting is useful when you arrived at your dependent values by measuring a number of discrete events with respect to the independent variable, such as counting the number of cars passing through an intersection over 10-minute intervals.
- **Instrumental Weighting** – Instrumental weighting is useful when you are measuring things from a scale, such as length, mass, voltage, or current, and you suspect that unequal errors have been introduced into the data by the measuring device. For example, if an ohm meter has three different scales (one for 0 to 1 ohm, one for 2 to 99 ohms, and one for 100 ohms or more), the weighting factor would be the same for each measurement taken with the same scale.

Tip In most cases, you would use a different weighting factor for each scale or instrument that was used to measure your original data.

- **No Weighting** – If you feel that fluctuations in your data are due to instrument error but that the uncertainties of the measuring device used are equal for all the data collected, you would probably specify no weighting ($wt = 1$).

Example

For an example, refer to the `gaussfit.pro` file in the Standard Library.

See Also

FUNCT, GAUSSFIT, POLY_FIT

CYLINDER Function

Defines a cylindrical object that can be used by the RENDER function.

Usage

result = CYLINDER( )

Parameters

None.

Returned Value

result — A structure that defines a cylinder object.

Input Keywords

Color — A 256-element double-precision floating-point vector containing the color (intensity) coefficients of the object. The default is `Color(*)=1.0.` For more information, see the section *Defining Color and Shading* on page 198 of the *PV-WAVE User's Guide.*

Decal — A 2D array of bytes whose elements correspond to indices into the arrays of material properties. For more information, see the section *Decals* on page 201 of the *PV-WAVE User's Guide.*

Kamb — A 256-element double-precision floating-point vector containing the ambient (flat shaded) coefficients. The default is `Kamb(*)=0.0`. For more information, see the section *Ambient Component* on page 199 of the *PV-WAVE User's Guide.*

Kdiff — A 256-element double-precision floating-point vector containing the diffuse reflectance coefficients. The default is `Kdiff(*)=1.0`. For more information, see the section *Diffuse Component* on page 198 of the *PV-WAVE User's Guide.*

Ktran — A 256-element double-precision floating-point vector containing the specular transmission coefficients. The default is `Ktran(*)=0.0`. For more information, see the section *Transmission Component* on page 199 of the *PV-WAVE User's Guide.*

Transform — A 4-by-4 double-precision floating-point array containing the local transformation matrix whose default is the identity matrix. For more information, see the section *Setting Object and View Transformations* on page 201 of the *PV-WAVE User's Guide.*

Discussion

A CYLINDER is used by the RENDER function to render cylindrical objects, such as for molecular modeling (symbolizing bonds), or for generating axes and 3D lines. It is defined as having a radius of 0.5 and being centered at the origin with a height of 0.5 in the +Z direction and 0.5 in the –Z direction.

To change the dimensions and orientation of a CYLINDER, use the *Transform* keyword.

Examples

```
T3D, /Reset, Rotate=[90, 0., 0]
c = CYLINDER(Transform=!P.T)
TV, RENDER (c)
```

See Also

CONE, MESH, RENDER, SPHERE, VOLUME

For more information, see *Ray-tracing Rendering* on page 196 of the *PV-WAVE User's Guide.*

DAY_NAME Function

Standard Library procedure that returns a string array or string constant containing the name of the day of the week for each day in a Date/Time variable.

Usage

result = DAY_NAME(*dt_var*)

Input Parameters

dt_var — A PV-WAVE Date/Time variable.

Returned Value

result — A string array or string constant containing the name of the day of the week for each input Date/Time value.

Keywords

None.

Discussion

The names of the days of the week are string values taken from the system variable !Day_Names.

Examples

```
date = TODAY( )
day = DAY_NAME(date)
PRINT, day
   Monday
```

See Also

DAY_OF_YEAR, DAY_OF_WEEK, MONTH_NAME

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV‑WAVE User's Guide*.

DAY_OF_WEEK Function

Returns an array of integers containing the day of the week for each date in a Date/Time variable.

Usage

result =DAY_OF_WEEK(*dt_var*)

Input Parameters

dt_var — A PV‑WAVE Date/Time variable.

Returned Value

result — The day of the week expressed as an integer. Day 0 is Sunday and day six is Saturday.

Keywords

None.

Examples

Assume that you have a PV‑WAVE Date/Time variable, `date`, for April 13, 1992. To find out which day of the week this date is, enter:

```
day = DAY_OF_WEEK(date)
PRINT, day
    1
```

The day is a Monday.

See Also

DAY_NAME, DAY_OF_YEAR, MONTH_NAME

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV-WAVE User's Guide.*

DAY_OF_YEAR Function

Returns an array of integers containing the day of the year for each date in a Date/Time variable.

Usage

result = DAY_OF_YEAR(*dt_var*)

Input Parameters

dt_var – A PV-WAVE Date/Time variable.

Returned Value

result – An array of integers representing the day of the year for each date in the input variable.

Keywords

None.

Discussion

The result falls in a range between 1 and 365 (or 366 if it is a leap year).

Examples

```
today = TODAY()
```

Create a PV-WAVE Date/Time variable.

```
daynumber = DAY_OF_YEAR(today)
```

```
PRINT, daynumber
   106
```

See Also

DAY_OF_WEEK, DAY_NAME, MONTH_NAME

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV-WAVE User's Guide*.

DBLARR Function

Returns a double-precision floating-point vector or array.

Usage

result = DBLARR(*dim*$_1$, ... , *dim*$_n$)

Input Parameters

dim$_i$ – The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result – A double-precision floating-point vector or array.

Input Keywords

Nozero – Normally, DBLARR sets every element of the result to zero. If *Nozero* is nonzero, this zeroing is not performed, causing DBLARR to execute faster.

Example

```
r = DBLARR(3, 3)
PRINT, r
   0.0000000   0.0000000   0.0000000
```

```
0.0000000    0.0000000    0.0000000
0.0000000    0.0000000    0.0000000
```

See Also

DINDGEN, DOUBLE, BYTARR, COMPLEXARR, FLTARR, INTARR, LONARR, MAKE_ARRAY

DC_ERROR_MSG Function

Returns the text string associated with the negative status code generated by a "DC" data import/export function that does not complete successfully.

Usage

msg_str = DC_ERROR_MSG(*status*)

Input Parameters

status – The error message number returned by any of the "DC" functions. Must be integer.

Returned Value

msg_str – The test string that corresponds to the value of *status*. Returns a string; the string is an empty (null) string if *status* is greater than or equal to 0 (zero).

Keywords

None.

Discussion

When *status* has a value less than 0 (zero), it indicates a "DC" function error condition, such as an invalid filename, or an unexpected end-of-file.

Because the error message number *status* includes both the error number and an ID number that corresponds to the "DC" function that produced the error, both the function name and the specific error are described in the message string returned by DC_ERROR_MSG.

Example

The following statements read a file containing 8-bit image data. Depending on the status returned by DC_READ_8_BIT, either an error message is written or the image is displayed in a window the exact size of the image:

```
status = DC_READ_8_BIT('mongo.img', $
   mongo, XSize=xs, YSize=ys)
   Use DC_READ_8_BIT to read the image file.

IF (status LT 0) THEN BEGIN
   msg_str = DC_ERROR_MSG(status)
      Obtain the error message if status has a negative value.
   PRINT, msg_str
      Print the error message.
ENDIF ELSE BEGIN
   WINDOW, XSize=xs, YSize=ys
      Define a window the right size to hold the image.
   TV, mongo
      Display the image inside the window.

ENDELSE
```

See Also

DC_OPTIONS

DC_OPTIONS Function

Sets the error message reporting level for all "DC" import/export functions.

Usage

status = DC_OPTIONS(*msg_level*)

Input Parameters

msg_level – The error message reporting level. Allowed values are:

0	No messages. All "DC" functions operate in a silent mode.
1	Error messages (messages that indicate a "DC" function has failed).
2	Error message plus warning messages (messages that indicate the "DC" function did something, but possibly not what the user expected).
3	Error message plus warning messages plus informational messages. All levels of error messages are reported.

Each level of message reporting includes all error message reporting levels with a lower value, as well. For example, Level 3 includes both Level 2 and Level 1 messages.

Returned Value

status – The value returned by DC_OPTIONS; expected values are:

< 0	Indicates an error, such as an invalid value for *msg_level.*
0	Indicates a successful interpretation of *msg_level.*

Keywords

None.

Discussion

By default, all messages are sent to LUN –2, the standard error stream (`stderr` for UNIX and `SYS$ERROR` for VMS).

If you are using DC_OPTIONS with an error message reporting level of 0, messages are not automatically sent to the standard error stream, but status codes are still being generated by the various "DC" functions. These status codes can be used as input to DC_ERROR_MSG; this is the way to obtain the corresponding error message string, a string that you can then process or display in any way that you choose to.

See Also

DC_ERROR_MSG

DC_READ_FIXED Function

Reads fixed-formatted ASCII data using a PV-WAVE format that you specify.

Usage

status = DC_READ_FIXED(*filename, var_list*)

Input Parameters

filename – A string containing the pathname and filename of the file containing the data.

Output Parameters

var_list – The list of PV-WAVE variables into which the data is read. Include as many variable names in *var_list* as you want to be filled with data, up to a maximum of 255. Note that variables of type structure are not supported. An exception to this is the !DT, or date/time, structure. It is possible to transfer date/time data using this routine.

Returned Value

status – The value returned by DC_READ_FIXED; expected values are:

< 0	Indicates an error, such as an invalid filename or an I/O error.
0	Indicates a successful read.

Input Keywords

Format – A string containing the C- or FORTRAN-like format statement that will be used to read the data. The format string must contain at least one format code that transfers data; FORTRAN formats must be enclosed in parentheses. If not provided, a C format of `%lf` is assumed.

Nrecs — Number of records to read. If not provided or if set equal to zero (0), the entire file is read. For more information about records, see *Physical Records vs. Logical Records* on page 165.

Nskip — Number of physical records in the file to skip before data is read. If not provided, or set equal to zero (0), no records are skipped.

Row — A flag that signifies *filename* is a row-organized file. If neither *Row* nor *Column* is present, *Row* is the default.

Column — A flag that signifies *filename* is a column-organized file.

Miss_Str — An array of strings that may be present in the data file to represent missing data. If not provided, PV-WAVE does not check for missing data as it reads the file. For an example showing how to use the *Miss_Str* keyword, see DC_READ_FREE, *Example 3* on page 186.

Miss_Vals — An array of integer or floating-point values, each of which corresponds to a string in *Miss_Str*. As PV-WAVE reads the input data file, occurrences of strings that match those in *Miss_Str* are replaced by the corresponding element of *Miss_Vals*.

Ignore — An array of strings; if any of these strings are encountered, PV-WAVE skips the entire record and starts reading data from the next line. Any string is allowed, but the following three strings have special meanings:

`$BLANK_LINES`	Skip all blank lines; this prevents those lines from being interpreted as a series of zeroes.
`$TEXT_IN_NUMERIC`	Skip any line where text is found in a numeric field.
`$BAD_DATE_TIME`	Skip any line where invalid date/time data is found.

For an example showing how to use the *Ignore* keyword, see *Example 7* on page 175.

Filters — An array of one-character strings that PV-WAVE should check for and filter out as it reads the data. A character found on the keyboard can be typed; a special character not found on the keyboard is specified by ASCII code. For more details, see *Example 2* on page 170.

Resize — An array of integers indicating the variables in *var_list* that can be resized based on the number of records detected in the input data file. Values in *Resize* should be in the range:

$$1 \le Resize_n \le \#\_of\_vars\_in\_var\_list$$

For an example showing how to use the *Resize* keyword, see *Example 4* on page 171.

Bytes_Per_Rec — A long integer that specifies how many characters comprise a single record in the input data file; use only with column-oriented files. If not provided, each line of data in the file is treated as a new record. For more details about when to use the *Bytes_Per_Rec* keyword, see *Example 5* on page 173.

Dt_Template — An array of integers indicating the data/time templates that are to be used for interpreting date/time data. Positive numbers refer to date templates; negative numbers refer to time templates. For more details, see *Example 6* on page 174. To see a complete list of date/time templates, see *Transferring Date/Time Data* on page 168 of the *PV-WAVE Programmer's Guide.*

Discussion

DC_READ_FIXED is capable of interpreting either FORTRAN- or C-style formats, and is very adept at reading column-oriented data files. Also, DC_READ_FIXED handles many steps that you have to do yourself when using other PV-WAVE functions and procedures. These steps include: 1) opening the file, 2) assigning it a logical unit number (LUN), and 3) closing the file when you are done reading the data.

If neither the *Row* or *Column* keywords are provided, the file is assumed to be organized by rows. If both keywords are used, the *Row* keyword is assumed.

Note This function can be used to read data into date/time structures, but not into any other kind of PV-WAVE structures.

How the Data is Transferred into Variables

As many as 255 variables can be included in the input argument *var_list*. You can use the continuation character ($) to continue the function call onto additional lines, if needed. Any undeclared variables in *var_list* are assumed to have a data type of float (single-precision floating-point).

As data is being transferred into multi-dimensional variables, those variables are treated as collections of scalar variables, meaning the first subscript of the import variable varies the fastest. For two-dimensional import variables, this implies that the column index varies faster than the row index. In other words, data is transferred into a two-dimensional import variable one row at a time. For more details about reading column-oriented data into multi-dimensional variables, see *Example 4* on page 187 (in the DC_READ_FREE function description).

The format string is processed from left to right. Record terminators and format codes are processed until no variables are left in the variable list or until an error occurs. In a FORTRAN format string, when a slash record terminator (/) is encountered, the rest of the current input record is ignored, and the next input record is read.

Format codes that transfer data are matched with the next available variable (or element of a multi-dimensional variable) in the variable list *var_list*. Data is read from the file and formatted according to the format code. If the data from the file does not agree with the format code, or the format code does not agree with the type of the variable, a type conversion is performed. If no type conversion is possible, an error results and a nonzero status is returned.

Once all variables in the variable list have been filled with data, DC_READ_FIXED stops reading data, and returns a status code of zero (0). This is true even if there are format codes in *Format* that did not get used. Even if an error occurs, and *status* is nonzero, the data that has been read successfully (prior to the error) is returned in the *var_list* variables.

Tip If an error does occur, use the PRINT command to view the contents of the variables to see where the last successfully read value occurs. This will enable you to isolate the portion of the file in which the error occurred.

If the format string does not contain any format codes that transfer data, an error occurs and a nonzero status is returned. The format codes that PV-WAVE recognizes are listed in Appendix A, *FORTRAN and C Format Strings*, in the *PV-WAVE Programmer's Guide.* If a format code that does not transfer data is encountered, it is processed as discussed in that appendix.

Format Reversion when Reading Data

If the last closing parenthesis of the format string is reached and there are still unfilled variables remaining, *format reversion* occurs. In format reversion, the current record is terminated, a new one is read, and format string processing reverts to the first group repeat specification that does not have an explicit repeat count. If the format does not contain a group repeat specification, format processing reverts to the initial opening parenthesis of the format string.

For more information about format reversion and group repeat specifications, see *Appendix A, FORTRAN and C Format Strings in the WAVE Programmer's Guide.*

Physical Records vs. Logical Records

In an ASCII text file, the end-of-line is signified by the presence of either a CTRL-J or a CTRL-M character, and a *record* extends from one end-of-line character to the next. However, there are actually two kinds of records:

- ✔ physical records
- ✔ logical records

For column-oriented files, the amount of data in a *physical record* is often sufficient to provide exactly one value for each variable in *var_list*, and then it is a *logical record*, as well. For row-oriented files, the concept of logical records is not relevant, since data is merely read as contiguous values separated by delimiters, and the end-of-line is merely interpreted as another delimiter.

Note The *Nrecs* keyword counts by logical records, if they have been defined. The *Nskip* keyword, on the other hand, counts by physical records, regardless of any logical record size that has been defined.

Changing the Logical Record Size

You can use the *Bytes_Per_Rec* keyword to explicitly define a different logical record size, if you wish. However, in most cases, you do not need to provide this keyword. For an example of when to use the *Bytes_Per_Rec* keyword, see *Example 5* on page 173.

Note By default, DC_READ_FIXED considers the physical record to be one line in the file, and the concept of a logical record is not needed. But if you *are* using logical records, the physical records in the file must all be the same length. The *Bytes_Per_Rec* keyword can be used only with column-oriented data files.

Filtering and Substitution While Reading Data

If you want certain characters filtered out of the data as it is read, use the *Filters* keyword to specify these characters. Each character (or sequence of digits that represents the ASCII code for a character) must be enclosed with single quotes. For example, either of the following is a valid specification:

```
',' or '44'
```

Furthermore, the two specifications shown above are equivalent to one another. For more examples of using the *Filters* keyword, see *Example 2* on page 170, or DC_READ_FREE, *Example 4* on page 187.

Characters that match one of the values in *Filters* are treated as if they aren't even there; in other words, these characters are not treated as data and do not contribute to the size of the logical record, if one has been defined using the *Bytes_Per_Rec* keyword.

Note If you want to supply multi-character strings instead of individual characters, you can do this with the *Ignore* keyword. However, keep in mind that a character that matches *Filters* is simply discarded, and filtering resumes from that point, while a string that matches *Ignore* causes that entire line to be skipped.

So if you are reading a data file that contains a value such as #$*10.00**, but you don't want the entire line to be skipped, filter the characters individually with *Filters = ['#', '$', '*']*, instead of collectively with *Ignore = ['#$*', '**']*.

Missing Data Substitution

PV-WAVE expects to substitute a value from *Miss_Vals* whenever it encounters a string from *Miss_Str* in the data. Consequently, if the number of elements in *Miss_Str* does not match the number of elements in *Miss_Vals*, a nonzero status is returned and no data is read. The maximum number of values permitted in *Miss_Str* and *Miss_Vals* is 10.

If the end of the file is reached before all variables are filled with data, the remainder of each variable is set to *Miss_Vals*(0) if it was specified, or 0 (zero) if *Miss_Vals* was not specified. In this case, *status* is returned with a value less than zero to signify an unexpected end-of-file condition.

Reading Row-Oriented Files

If you include the *Row* keyword, each variable in *var_list* is completely filled before any data is transferred to the next variable.

The dimensionality of the last variable in *var_list* can be unknown; a variable of length *n* is created, where *n* is the number of values remaining in the file. All other variables in *var_list* must be predimensioned.

If you include the *Resize* keyword with the call to DC_READ_FIXED, the last variable can be redimensioned to match the actual number of values that were transferred to the variable during the read operation.

If you are interested in an illustration showing what row-oriented data can look like inside a file, see *Row-Oriented ASCII Data Files* on page 146 of the *PV-WAVE Programmer's Guide.*

Reading Column-Oriented Files

If you include the *Column* keyword, DC_READ_FIXED views the data files as a series of columns, with a one-to-one correspondence between columns in the file and variables in the variable list. In other words, one value from the first record of the file is transferred into each variable in *var_list*, then another value from the next record of the file is transferred into each variable in *var_list*, and so forth, until all the data in the file has been read, or until the variables are completely filled with data.

If a variable in *var_list* is undefined, a floating-point variable of length *n* is created, where *n* is the number of records read from the file. To get a similar effect in an existing variable, include the *Resize* keyword with the function call.

All variables specified with the *Resize* keyword are redimensioned to the same length – the length of the longest column of data in the file. The variables that correspond to the shortest columns in the file will have one or more values added to the end; either *Miss_Vals*(0) if it was specified, or 0 (zero) if *Miss_Vals* was not specified.

If you are interested in an illustration demonstrating what column-oriented data can look like inside a file, see *Column-Oriented ASCII Data Files* on page 144 of the *PV-WAVE Programmer's Guide.*

Multi-dimensional Variables

The following table shows how column-oriented data in a file is read into multi-dimensional PV-WAVE variables:

Table 2-1: Reading Data from a Column-Oriented File

Dimensions of Variable	How Data is Read From the File (If Variable is Pre-dimensioned)
One-dimensional (*1* x *n*)	One value read from each record of file (repeated *n* times)
Two-dimensional (*m* columns by *n* rows)	*m* values read from each record of file (repeated *n* times)
Three-dimensional (*m* x *n* x *p*)	*m* values read from each record of file (repeated *n* times) (entire process repeated *p* times)
q-dimensional (*m* x *n* x *p* x *q*)	*m* values read from each record of file (repeated *n* times) (above process repeated *p* times) (entire process repeated *q* times).

You can combine one- and two-dimensional variables in *var_list*, as long as the second dimension of the two-dimensional variable matches the dimension of the one-dimensional variable. For example, with two variables, `var1(50)` and `var2(2,50)`, one column of data will be transferred to `var1` and two columns of data will be transferred to `var2`.

Caution If you want to intermingle multi-dimensional variables in *var_list*, you must be sure that the product of all dimensions (excluding the first dimension) of each variable is equal. For example, you can combine two-, three-, and four-dimensional variables in *var_list* if the variables have dimensions like these:

Var1	2-by-30
Var2	2-by-15-by-2
Var3	2-by-10-by-3
Var4	2-by-3-by-2-by-5

Example 1

The function call:

```
status = DC_READ_FIXED('results.wp', /Col, $
   unit1, unit2, unit3, run_total, Ignore= $
   ["Total", "------", "$TEXT_IN_NUMERIC", $
   "$BLANK_LINES"], Format="(F7.2,5X)")
```

reads the data from file `results.wp` and places the data into four PV-WAVE variables: `unit1`, `unit2`, `unit3`, and `run_-total`.

Because the variables were not predefined, all data is interpreted as single-precision floating-point data, and all variables are treated as resizable one-dimensional arrays. Any blank lines or strings specified with the *Ignore* keyword (in this example, "`Total`" and "`------`") are ignored. Also, any line with non-numeric characters in a numeric field is ignored.

Example 2

The function call:

```
status = DC_READ_FIXED('yields.doc', intake, $
   chute, conveyor, crusher, /Col, $
   Filter=['/', ':', ','], $
   Format="(F7.2, 8X, F6.4, 3X)", $
   Ignore=["$BLANK_LINES"])
```

reads data from the file `yields.doc` and places the data into four PV-WAVE variables: `intake`, `chute`, `conveyor`, and `crusher`.

Because the variables were not predefined, all data is interpreted as single-precision floating-point data, and all variables are treated as resizable one-dimensional arrays. Any extraneous characters (in this example, "/", ":", and ",") are discarded because the *Filter* keyword is provided. Also, all totally blank lines in the file are ignored.

Example 3

The data file shown below is a fixed-formatted ASCII file named `simple.dat`. The '.' characters in `simple.dat` represent blank spaces:

```
...1...2...3...4...5
...6...7...8...9..10
..11..12..13..14..15
..16..17..18..19..20
```

The function call:

```
status = DC_READ_FIXED('simple.dat', var1, $
   Format='(I4)', /Col)
```

results in `var1=[1.0, 6.0, 11.0, 16.0]`. Because `var1` was not predefined, DC_READ_FIXED creates it as a one-dimensional floating-point array.

On the other hand, the commands:

```
Var1 = INTARR(2)
Var2 = INTARR(2)
status = DC_READ_FIXED('simple.dat', var1, $
   var2, Format='(2(4X, I4))', Nskip=2)
```

skip the first two records in the file and result in `var1=[12, 14]` and `var2=[17, 19]`. Because neither the *Row* or *Column* keyword was supplied, the file is assumed to use row organization.

Example 4

The data file shown below is a fixed-formatted ASCII file; this file is named `nimrod.dat`. The '.' characters in `nimrod.dat` represent blank spaces. `nimrod.dat` is very much like the data file in *Example 3* on page 171, except that it has a missing value where you would expect to see the numeral "8":

```
...1...2...3...4...5
...6...7.......9..10
..11..12..13..14..15
..16..17..18..19..20
```

When reading this file as column-oriented data, the results vary, depending on whether a C or FORTRAN format string is being used, and whether the *Resize* keyword has been included in the function call to DC_READ_FIXED.

For example, the commands:

```
A = INTARR(20) & B = INTARR(20)
C = INTARR(20) & D = INTARR(20)
E = INTARR(20)
status = DC_READ_FIXED('nimrod.dat', $
   A, B, C, D, E, Format='(2X, I2)', $
   Resize=[1, 2, 3, 4, 5], /Col)
```

result in `A=[1, 6, 11, 16]`, `B=[2, 7, 12, 17]`, `C=[3, 0, 13, 18]`, `D=[4, 9, 14, 19]`, and `E=[5, 10, 15, 20]`. The missing value is interpreted as a zero (0). All variables are resized to a length of 4.

On the other hand, the commands:

```
A = INTARR(20) & B = INTARR(20)
C = INTARR(20) & D = INTARR(20)
E = INTARR(20)
status = DC_READ_FIXED('nimrod.dat', $
   A, B, C, D, E, Format='%d', $
   Resize=[1, 2, 3, 4, 5], /Col)
```

result in `A=[1, 6, 11, 16]`, `B=[2, 7, 12, 17]`, `C = [3, 9, 13, 18]`, `D = [4, 10, 14, 19]`, and `E = [5, 15, 20]`. The missing value is skipped altogether, and E is resized to a length of 3 to reflect the number of values that were transferred into the variable. The other variables are resized to 4.

Any variable that is not resizable (because it was omitted from the *Resize* vector), will be padded to the end with extra values. For the latter of the two calls to DC_READ_FIXED shown in this example, A, B, C, and D would be padded with an additional 16 zeroes, while E would be padded with an additional 17 zeroes. (Zeroes are used for the padding because *Miss_Vals* was not specified.)

Note If the file `nimrod.dat` had used some other character as a delimiter, such as commas or slashes, both the C and FORTRAN format strings would have yielded the same result, namely, `C = [3, 0, 13, 18]`. It is only because of the way a C format skips over blank space that the C format was unable to detect the presence of a missing value.

Example 5

The data file shown below contains 18 pairs of XY data that could be used to create a PV-WAVE scatter plot:

```
5.992E+04,7.121E–01,8.348E+04,7.562E–01,5.672E+04,9.451E–01,
5.459E+04,8.659E–01,7.088E+04,8.659E–01,8.541E+04,3.437E–01,
4.981E+04,4.679E–01,8.438E+04,5.019E–01,6.902E+04,7.340E–01,
6.239E+04,8.023E–01,7.865E+04,6.643E–01,5.870E+04,9.992E–01,
7.439E+04,9.456E–01,4.672E+04,9.801E–01,6.872E+04,4.325E–01,
6.362E+04,5.894E–01,8.992E+04,7.509E–01,2.785E+04,4.796E–01,
```

For data organized like this, you use the *Bytes_Per_Rec* keyword to specify the exact length of the record. In this example, all X values are single-precision floating-point numbers with an exponent of E+04, and all Y values are single-precision floating-point numbers with an exponent of E–01. Therefore, each XY pair uses 18 ASCII characters (bytes) apiece. Thus, you would specify 20 bytes per record (9 times 2, plus 2 more bytes for the comma delimiters separating values).

```
   status = DC_READ_FIXED(/Col, "xy5.dat", Xa, $
      Ya, Format="(E9.3, 1X)", Bytes_Per_Rec=20)
```

If you omit the *Bytes_Per_Rec* keyword, but still read the file as a column-oriented file, only the first pair of data values on each line would actually be transferred into the variables `Xa` and `Ya`. Nor can the file be read as row-oriented data, because `Xa` would be filled completely before any data was transferred to `Ya`.

Tip Only include the *Bytes_Per_Rec* keyword when you have a logical record that is longer or shorter than one line in the file. For the majority of column-oriented data files, one and only one value from each variable is on a single line, and the *Bytes_Per_Rec* keyword is completely unnecessary.

Example 6

Assume that you have a file, `chrono.dat`, that contains some data values and also some chronological information about when those data values were recorded:

```
01/01/92 10:30:35 10.00 04-30-92 32767
02/01/92 23:22:15 15.89 06-15-91 99999
05/15/91 03:03:03 14.22 12-25-92 87654
```

The date/time templates that will be used to transfer this data have the following definitions:

Number	Template Description
1	MM*DD*YY (* = any delimiter)
–1	HH*MM*SS (* = any delimiter)

To read the date and time from the first two columns into one date/time variable and read the third column of floating point data into another variable, use the following PV-WAVE commands:

```
date1 = REPLICATE({!DT},3)
date2 = REPLICATE({!DT},3)
```

The system structure definition of date/time is !DT. Date/time variables must be defined as !DT structure arrays before being used if the date/time data is to be read as such.

```
status = DC_READ_FIXED("chrono.dat", date1, $
   date1, decibels, Dt_Template=[1,-1], $
   Format="(2(A8, 1X), F5.2)", /Col)
```

The variable date1 is listed twice; this way, both the date data and the time data can be stored in the same variable, date1.

To read all columns, change the call to DC_READ_FIXED and define a new variable:

```
calib = INTARR(3)
status = DC_READ_FIXED("chrono.dat", date1, $
    date1, decibels, date2, calib, /Col, $
    Format="%8s %8s %f %8s %d", Ignore= $
    ["$BAD_DATE_TIME"], Dt_Template=[1,-1])
```

Notice how the date/time templates are reused. For each new record, Template 1 is used first to read the *date* data into `date1`. Next, Template –1 is used to read the *time* data into `date1`. Finally, since there is another date/time variable to be read (`date2`) and there are no more templates left, the template list is reset and Template 1 is used again. The template list is reset for each record.

Note Because of the internal conversion that DC_READ_FIXED performs to convert the date strings to PV-WAVE's date/time internal structure, the date and time data *must* be read with the `A8` (FORTRAN) or `%8s` (C) format string.

Normally an error would be reported if the input text to be read as date/time is invalid and cannot be converted. But because the *Ignore=["$BAD_DATE_TIME"]* keyword was provided, any record containing this type of error is ignored and no error is reported.

Example 7

The data file shown below is a fixed-formatted ASCII file named `wages.wp`. All floating-point data in the file has been decimal-point-aligned by a word-processing application:

```
1070.0    9007.97    1100.0    1250.0     850.5    2010.0
5000.0    3050.0     1044.12   3500.0    6031.0     905.0

 415.0    5200.0     1300.10    350.0     745.0    3000.0
 200.0    3100.0     8100.0    7050.0    6780.0    2310.25

 950.0    1050.0     1350.0     410.0     797.0     200.36
2600.0    2000.0     1500.0    2000.0    1000.0     400.0

1000.0    9000.0     1100.0    2091.0    3440.10   2000.37
5000.0    3000.0     1000.01   3500.0    6000.0     900.12
```

The following PV-WAVE commands:

```
Maria = Fltarr(12) & Naomi = Fltarr(12)
Klaus = Fltarr(12) & Carlos = Fltarr(12)
status = DC_READ_FIXED('wages.wp', Maria, $
   Carlos, Klaus, Naomi, Format="(F7.2,5X)", $
   Ignore=["$BLANK_LINES"])
```

read the data from file `wages.wp` and places the data into four PV-WAVE variables: `Maria`, `Carlos`, `Klaus`, and `Naomi`. By default, row organization is assumed in the file, with five spaces separating the values in the file.

With row organization, each variable is "filled up" before any data is transferred to the next variable in the variable list. This means that the first two lines of the file are transferred into the variable `Maria`, the new two lines of the file are transferred into the variable `Carlos`, the next two lines of the file are transferred into the variable `Klaus`, and the last two lines of the file are transferred into the variable `Naomi`. The blank lines in the file are skipped entirely, preventing those lines from being interpreted as a series of zeroes.

See Also

DC_READ_FREE, DC_WRITE_FIXED, DC_ERROR_MSG

See *Explicitly Formatted Input and Output* on page 165 of the *PV-WAVE Programmer's Guide* for more information about fixed format I/O in PV-WAVE.

DC_READ_FREE Function

Reads freely-formatted ASCII files.

Usage

status = DC_READ_FREE(*filename, var_list*)

Input Parameters

filename – A string containing the pathname and filename of the file containing the data.

Output Parameters

var_list – The list of PV-WAVE variables into which the data is read. Include as many variables names in *var_list* as you want to be filled with data, up to a maximum of 255. Note that variables of type structure are not supported. An exception to this is the !DT, or date/time, structure. It is possible to transfer date/time data using this routine.

Returned Value

status – The value returned by DC_READ_FREE; expected values are:

< 0	Indicates an error, such as an invalid filename or an I/O error.
0	Indicates a successful read.

Input Keywords

Delim – An array of single-character strings that are the field separators used in the data file. If not provided, a comma- or space-delimited file is assumed.

Get_Columns — An array of integers indicating column numbers to read in the file. If not provided or if set equal to zero (0), all columns are read. Ignored if the *Row* keyword is supplied.

Nrecs — Number of records to read. If not provided or if set equal to zero (0), the entire file is read. For more information about records, see *Physical Records vs. Logical Records* on page 181.

Nskip — Number of physical records in the file to skip before data is read. If not provided or if set equal to zero (0), no records are skipped.

Row — A flag that signifies *filename* is a row-organized file. If neither *Row* nor *Column* is present, *Row* is the default.

Column — A flag that signifies *filename* is a column-organized file.

Miss_Str — A string array that specifies strings that may be present in the data file to represent missing data. If not present, PV-WAVE does not check for missing data as it reads the file.

Miss_Vals — An array of floating-point values, each of which corresponds to a string in *Miss_Str.* As PV-WAVE reads the input data file, occurrences of strings that match those in *Miss_Str* are replaced by the corresponding element of *Miss_Vals.*

Ignore — An array of strings; if any of these strings are encountered, PV-WAVE skips the entire line and starts reading data from the next line. Any string is allowed, but the following three strings have special meanings:

`$BLANK_LINES`	Skip all blank lines; this prevents those lines from being interpreted as a series of zeroes.
`$TEXT_IN_NUMERIC`	Skip any line where text is found in a numeric field.
`$BAD_DATE_TIME`	Skip any line where invalid date/time data is found.

For an example showing how to use the *Ignore* keyword, see *Example 2* on page 185.

Filters – An array of one-character strings that PV-WAVE should check for and filter out as it reads the data. A character found on the keyboard can be typed; a special character not found on the keyboard is specified by ASCII code. For more details about the *Filters* keyword, see *Filtering and Substitution While Reading Data* on page 182.

Resize – An array of integers indicating the variables in *var_list* that can be resized based on the number of records detected in the input data file. Values in *Resize* should be in the range:

$$1 \le Resize_n \le \#\_of\_vars\_in\_var\_list$$

For an example showing how to use the *Resize* keyword, see DC_READ_FIXED, *Example 4* on page 171, or DC_READ_FREE, *Example 4* on page 187.

Vals_Per_Rec – A long integer that specifies how many values comprise a single record in the input data file; use only with column-oriented files. If not provided, each line of data in the file is treated as a new record. For more details about when to use the *Vals_Per_Rec* keyword, see *Example 4* on page 187.

Dt_Template – An array of integers indicating the date/time templates that are to be used for interpreting date/time data. Positive numbers refer to date templates; negative numbers refer to time templates. For more details, see *Example 5* on page 189. To see a complete list of date/time templates, see *Transferring Date/Time Data* on page 168 of the *PV-WAVE User's Guide.*

Discussion

DC_READ_FREE is very adept at reading column-oriented data files. Also, DC_READ_FREE handles many steps that you have to do yourself when using other PV-WAVE functions and procedures. These steps include: 1) opening the file, 2) assigning it a logical unit number (LUN), and 3) closing the file when you are done reading the data.

DC_READ_FREE relieves you of the task of composing a format string that describes the organization of the data in the input file. All you do is tell DC_READ_FREE which delimiters to expect in the file; comma and space are the default delimiters expected. In other words, DC_READ_FREE easily reads data values separated by any combination of commas and spaces, or any other delimiters that you explicitly define using the *Delim* keyword.

If neither the *Row* or *Column* keywords are provided, the file is assumed to be organized by rows. If both keywords are used, the *Row* keyword is assumed.

Note This function can be used to read data into date/time structures, but not into any other kind of PV-WAVE structures.

How the Data is Transferred into Variables

As many as 255 variables can be included in the input argument *var_list*. You can use the continuation character ($) to continue the function call onto additional lines, if needed. Any undeclared variables in *var_list* are assumed to have a data type of float (single-precision floating-point).

As data is being transferred into multi-dimensional variables, those variables are treated as collections of scalar variables, meaning the first subscript of the import variable varies the fastest. For two-dimensional import variables, this implies that the column index varies faster than the row index. In other words, data is transferred into a two-dimensional import variable one row at a time. For more details about reading column-oriented data into multi-dimensional variables, see *Example 4* on page 187.

If the current input line is empty or DC_READ_FREE has reached the end of the line and there are still unused variables in *var_list*, the next line is read. When there are no unused variables left in *var_list*, the remainder of the line is ignored.

When reading into numeric variables, PV-WAVE attempts to convert the input into a value of the expected type. Decimal points are optional and scientific notation is allowed. If a real value is provided for an integer variable, the value is truncated at the decimal point.

Note If the file contains string data, make sure the strings do not contain delimiter characters. Otherwise, the string will be interpreted as more than one string, and the data in the file will not match the variable list.

Once all variables in the variable list have been filled with data, DC_READ_FREE stops reading data, and returns a status code of zero (0). Even if an error occurs, and *status* is nonzero, the data that has been read successfully (prior to the error) is returned in the *var_list* variables.

Tip If an error does occur, use the PRINT command to view the contents of the variables to see where the last successfully read value occurs. This will enable you to isolate the portion of the file in which the error occurred.

Physical Records vs. Logical Records

In an ASCII text file, the end-of-line is signified by the presence of either a CTRL-J or a CTRL-M character, and a *record* extends from one end-of-line character to the next. However, there are actually two kinds of records:

- ✔ physical records
- ✔ logical records

For column-oriented files, the amount of data in a *physical record* is often sufficient to provide exactly one value for each variable in *var_list*, and then it is a *logical record*, as well. For row-oriented files, the concept of logical records is not relevant, since data is merely read as contiguous values separated by delimiters, and the end-of-line is merely interpreted as another delimiter.

Note The *Nrecs* keyword counts by logical records, if they have been defined. The *Nskip* keyword, on the other hand, counts by physical records, regardless of any logical record size that has been defined.

Changing the Logical Record Size

You can use the *Vals_Per_Rec* keyword to explicitly define a different logical record size, if you wish. However, in most cases, you do not need to provide this keyword. For an example of when to use the *Vals_Per_Rec* keyword, see *Example 4* on page 187.

Note By default, DC_READ_FREE considers the physical record to be one line in the file, and the concept of a logical record is not needed. But if you *are* using logical records, the physical records in the file must all contain the same number of values. The *Vals_Per_Rec* keyword can be used only with column-oriented data files.

Filtering and Substitution While Reading Data

If you want certain characters filtered out of the data as it is read, use the *Filters* keyword to specify these characters. Each character (or sequence of digits that represents the ASCII code for a character) must be enclosed with single quotes. For example, either of the following is a valid specification:

```
',' or '44'
```

Furthermore, the two specifications shown above are equivalent to one another. For another example of using the *Filters* keyword, see *Example 4* on page 187.

Tip Be sure not to filter characters that were used in the file as delimiters. The delimiters enable DC_READ_FREE to discern where one data value ends and another one begins.

Characters that match one of the values in *Filters* are treated as if they aren't even there; in other words, these characters are not treated as data and do not contribute to the size of the logical record, if one has been defined using the *Vals_Per_Rec* keyword.

Note If you want to supply multi-character strings instead of individual characters, you can do this with the *Ignore* keyword. However, keep in mind that a character that matches *Filters* is simply discarded, and filtering resumes from that point, while a string that matches *Ignore* causes that entire line to be skipped.

So if you are reading a data file that contains a value such as #$*10.00**, but you don't want the entire line to be skipped, filter the characters individually with *Filters = ['#', '$', '*']* instead of collectively with *Ignore = ['#$*', '**']*.

Missing Data Substitution

PV-WAVE expects to substitute a value from *Miss_Vals* whenever it encounters a string from *Miss_Str* in the data. Consequently, if the number of elements in *Miss_Str* does not match the number of elements in *Miss_Vals*, a nonzero status is returned and no data is read. The maximum number of values permitted in *Miss_Str* and *Miss_Vals* is 10.

If the end of the file is reached before all variables are filled with data, the remainder of each variable is set to *Miss_Vals*(0) if it was specified, or 0 (zero) if *Miss_Vals* was not specified. In this case, *status* is returned with a value less than zero to signify an unexpected end-of-file condition.

Delimiters in the Input File

Values in the file can be separated by commas, spaces, and any other delimiter characters specified with the *Delim* keyword. If you use any other delimiter, the delimiter character is treated as data and type conversion is attempted. If type conversion is not possible, *status* is set to less than zero to signify an error condition.

Caution Use a different delimiter to separate data values in the file than you use to separate the different fields of dates and times, such as months, days, hours, and minutes. Otherwise, your date/time data may not be interpreted correctly. The only delimiters that can be used inside date/time data are: slash (/), colon (:), hyphen (–), and comma (,).

Reading Row-Oriented Files

If you include the *Row* keyword, each variable in *var_list* is completely filled before any data is transferred to the next variable.

When reading row-oriented data, only the dimensionality of the last variable in *var_list* can be unknown; a variable of length *n* is created, where *n* is the number of values remaining in the file. All other variables in *var_list* must be pre-dimensioned.

If you include the *Resize* keyword with the call to the function DC_READ_FREE, the last variable can be redimensioned to match the actual number of values that were transferred to the variable during the read operation.

If you are interested in an illustration showing what row-oriented data can look like inside a file, see *Row-Oriented ASCII Data Files* on page 146 of the *PV-WAVE Programmer's Guide.*

Reading Column-Oriented Files

If you include the *Column* keyword, DC_READ_FREE views the data files as a series of columns, with a one-to-one correspondence between columns in the file and variables in the variable list. In other words, one value from the first record of the file is transferred into each variable in *var_list*, then another value from the next record of the file is transferred into each variable in *var_list*, and so forth, until all the data in the file has been read, or until the variables are completely filled with data.

If a variable in *var_list* is undefined, a floating-point variable of length *n* is created, where *n* is the number of records read from the file. To get a similar effect in an existing variable, include the *Resize* keyword with the function call.

All variables specified with the *Resize* keyword are redimensioned to the same length – the length of the longest column of data in the file. The variables that correspond to the shortest columns in the file will have one or more values added to the end; either *Miss_Vals*(0) if it was specified, or 0 (zero) if *Miss_Vals* was not specified.

If you are interested in an illustration demonstrating what column-oriented data can look like inside a file, see *Column-Oriented ASCII Data Files* on page 144 of the *PV-WAVE Programmer's Guide.*

For more information about how column-oriented data in a file is read into multi-dimensional PV-WAVE variables, see *Multi-dimensional Variables* on page 169.

Example 1

The data file shown below is a freely-formatted ASCII file named `monotonic.dat`:

```
1 2 3 4 5
 6 7 8 9 10
11 12 13 14 15
 16 17 18 19 20
```

The function call:

```
status = DC_READ_FREE('monotonic.dat', var1, $
   /Col, Get_Columns=[3])
```

results in `var1=[3.0, 8.0, 13.0, 18.0]`. Because `var1` was not predefined, DC_READ_FREE creates it as a resizable one-dimensional floating-point array.

On the other hand, the commands:

```
var1 = INTARR(2)
var2 = INTARR(2)
status = DC_READ_FREE('monotonic.dat', var1, $
   var2, /Col, Get_Columns=[2, 4], Nskip=2)
```

result in `var1=[12, 17]` and `var2=[14, 19]`.

Example 2

The data file shown below is a freely-formatted ASCII file named `measure.dat`:

```
0  5  10  15  20  25  30  35  40  45  50  56
   61  66  71  76  81  86  91


 96 101 107 112 117 122 127 132 137 142 147
   152 158 163 168 173 178 183 188


 193 198 203 209 214 219 224 229 234 239 244
   249 255 255 255 255 255 255 255


 255 255 255 255 255
```

The commands:

```
var1 = INTARR(5)
var2 = INTARR(5)
status = DC_READ_FREE('measure.dat', $
   var1, var2, Ignore=["$BLANK_LINES"])
```

result in `var1 = [0, 5, 10, 15, 20]` and `var2 = [25, 30, 35, 40, 45]`. Note that the file was interpreted as row-oriented data, since neither the *Row* or *Column* keyword was specified. All totally blank lines are ignored

Note If the *Resize = [2]* keyword had been provided, `var2` would have been resizable and would have ended up having many more elements. Specifically, `var2` would have ended up with 57 elements instead of just 5.

Example 3

The data file shown below is a freely-formatted ASCII file named `intake.dat`:

```
151-182-BADY-214-515
316-197-BADX-199-206
```

The commands:

```
valve = INTARR(30)
status = DC_READ_FREE('intake.dat', $
   valve, Miss_Str=["BADX","BADY"], $
   Miss_Vals=[9999, –9999], Resize=[1], $
   Delim=['-'])
```

results in `valve=[151, 182, –9999, 214, 515, 316, 197, 9999, 199, 206]`. The hyphens in the data are filtered out. Because `valve` is resizable, it ends up with 10 elements instead of 30. The two values from *Miss_Vals* are substituted for the two strings in the file, `"BADX"` and `"BADY"`.

Example 4

The data file shown below is a freely-formatted ASCII file named `level.dat`. This data file uses the semi-colon (;) and the slash (/) as delimiters, and the comma (,) to separate the thousands digit from the hundreds digit. This file has three logical records on every line; at the end of each logical record is a slash:

```
5,992;17,121/8,348;17,562/
5,672;19,451/
5,459;18,659/7,088;17,052/
8,541;13,437/
6,362;15,894/8,992;17,509/
7,785;14,796/
```

The commands:

```
gap = INTARR(20)
bar = INTARR(20)
status = DC_READ_FREE('level.dat', gap, bar, $
   /Col, Delim=[';', '/'], Filter=[','], $
   Resize=[1, 2], Vals_Per_Rec=2)
```

`result` in `gap = [5992, 8348, 5672, 5459, 7088, 8541, 6362, 8992, 7785]` and `bar = [17121, 17562, 19451, 18659, 17052, 13437, 15894, 17509, 14796].`

The commas have been filtered out of the data because of the value of the string that was provided with the *Filter* keyword.

Suppose you wanted `gap` and `bar` to be dimensioned as 3-by-3 arrays instead of 1-by-9 vectors. The best way to do this is by reading the data with the commands shown above, and then using the REFORM command to redimension the variables:

```
gaparr = REFORM(gap, 3, 3)
bararr = REFORM(bar, 3, 3)
```

By approaching the data transfer in this way, DC_READ_FREE does not expect to transfer two columns of data into the same multi-dimensional variable.

For example, the following commands demonstrate the problem:

```
gap = INTARR(3, 3)
bar = INTARR(3, 3)
status = DC_READ_FREE('level.dat', gap, bar, $
   /Col, Delim=[';', '/'], Filter=[','], $
   Resize=[1, 2], Vals_Per_Rec=2)
```

```
result in:
```

$$gap = \begin{bmatrix} 5992 & 17121 & 0 \\ 8348 & 17562 & 0 \\ 5672 & 19451 & 0 \\ 5459 & 18659 & 0 \\ 7088 & 17052 & 0 \\ 8541 & 13437 & 0 \\ 6362 & 15894 & 0 \\ 8992 & 17509 & 0 \\ 7785 & 14796 & 0 \end{bmatrix}$$

and

$$bar = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

The data is transferred into gap using the rule, “The first subscript varies fastest.” With *Vals_Per_Rec* set to “2”, no value is available for the third column – hence, every element in the third column is set equal to “0” (zero). Furthermore, notice that gap gets all the data (it is resizable) and bar gets none of the data.

Example 5

Assume that you have a file, `events.dat`, that contains some data values and also some chronological information about when those data values were recorded:

```
01/01/92 5:45:12 10 01-01-92 3276
02/01/92 10:10:10 15.89 06-15-91 99
05/15/91 2:02:02 14.2 12-25-92 876
```

The date/time templates that will be used to transfer this data have the following definitions:

Number	Template Description
1	MM*DD*YY (* = any delimiter)
–1	HH*MM*SS (* = any delimiter)

To read the date and time from the first two columns into one date/time variable and read the third column of floating point data into another variable, use the following PV-WAVE commands:

```
date1 = REPLICATE({!DT},3)
```

The system structure definition of date/time is !DT. Date/time variables must be defined as !DT structure arrays before being used if the date/time data is to be read as such.

```
status = DC_READ_FREE("events.dat", date1, $
   date1, float1, /Col, Dt_Template=[1,-1], $
   Delim=[' '])
```

The variable date1 is listed twice; this way, both the date data and the time data can be stored in the same variable, date1

To see the values of the two variables, you can use the PRINT command:

```
FOR I = 0,2 DO BEGIN
   PRINT, date1(I), float1(I)
```

Print one row at a time.

```
ENDFOR
```

Executing these statements results in the following output:

```
{ 1992     01     01     05     45     12.00
      87402.240    0} 10.0000      { 1992    02
      01     10     10     10.00     87433.424
      0} 15.8900      { 1992     05     15     02
      02     02.00     87537.035     0} 14.2000
```

Because `date1` is a structure, curly braces, "{" and "}", are placed around the output. When displaying the value of `date1` and `float1`, PV-WAVE uses default formats for formatting the values, and attempts to place as many items as possible onto each line.

Tip Another alternative to view the contents of `date1` and `float1` is to use the DT_PRINT command instead of PRINT.

Note For more information about the internal organization of the !DT system structure, see *The PV-WAVE Date/Time Structure* on page 225 of the *PV-WAVE User's Guide.*

To read the first, second, fourth, and fifth columns, define an integer array and another date/time variable, and change the call to DC_READ_FREE as shown below:

```
calib = INTARR(3)
date2 = REPLICATE({!DT},3)
status = DC_READ_FREE("events.dat", date1, $
   date1, date2, calib, /Col, Delim=[' '], $
   Get_Columns= [1, 2, 4, 5], Dt_Template=$
   [1, -1], Ignore=["$BAD_DATE_TIME"])
```

Notice how the date/time templates are reused. For each new record, Template 1 is used first to read the *date* data into `date1`. Next, Template –1 is used to read the *time* data into `date1`. Finally, since there is another date/time variable to be read (`date2`) and there are no more templates left, the template list is reset and Template 1 is used again. The template list is reset for each record.

Note Because of the internal conversion that DC_READ_FIXED performs to convert the date strings to PV-WAVE's date/time internal structure, the date and time data *must* be read with the `A8` (FORTRAN) or `%8s` (C) format string.

Normally an error would be reported if the input text to be read as date/time is invalid and cannot be converted. But because the *Ignore=["$BAD_DATE_TIME"]* keyword was provided, any record containing this type of error is ignored and no error is reported.

See Also

DC_READ_FIXED, DC_WRITE_FREE, DC_ERROR_MSG

See *Free Format Input and Output* on page 159 of the *PV-WAVE Programmer's Guide* for more information about free format I/O in PV-WAVE.

DC_READ_8_BIT Function

Reads an 8-bit image file.

Usage

status = DC_READ_8_BIT(*filename, imgarr*)

Input Parameters

filename — A string containing the pathname and filename of the 8-bit image file.

Output Parameters

imgarr — The byte array into which the 8-bit image data is read.

Returned Value

status — The value returned by DC_READ_8_BIT; expected values are:

< 0	Indicates an error, such as an invalid filename.
0	Indicates a successful read.

Output Keywords

XSize — The width (size in the X direction) of *imgarr. XSize* is computed and output if *imgarr* is not explicitly dimensioned. *XSize* is returned as an integer.

YSize — The height (size in the Y direction) of *imgarr. YSize* is computed and output if *imgarr* is not explicitly dimensioned. *YSize* is returned as an integer.

Discussion

DC_READ_8_BIT handles many steps that you have to do yourself when using other PV-WAVE functions and procedures. These steps include: 1) opening the file, 2) assigning it a logical unit number (LUN), and 3) closing the file when you are done reading the data.

If the dimensions of the byte array *imgarr* are not known, DC_READ_8_BIT makes a "best guess" about the width and height of the image. It guesses by checking the number of bytes in the file and comparing that number to the number of bytes associated with the following common image sizes:

Image Width	Image Height
640	480
640	512
128	128
256	256
512	512
1024	1024

If no match is found, DC_READ_8_BIT resorts to assuming that the image is square, and returns *XSize* and *YSize* as the square root of the number of bytes in the file.

Note You do not need to explicitly dimension *imgarr*, but if your image data is not one of the standard sizes shown above, you will get more predictable results if you dimension *imgarr* yourself.

Example

If `still_life.img` is a 640-by-480 image file, the function call:

```
status = DC_READ_8_BIT('still_life.img', $
   s_life, XSize=xdim, YSize=ydim)
```

reads the binary data in the file `still_life.img` and transfers it to a variable named `s_life`. It also returns `xdim=640` and `ydim=480`, since these keywords were provided in the function call.

On the other hand, if `still_life.img` is a 200-by-350 image file, the values returned are `xdim=264` and `ydim=264`. `xdim` and `ydim` are computed by taking the square root of the number of bytes in the file, since 200-by-350 is not one of the "common" image sizes that DC_READ_8_BIT checks for.

See Also

DC_WRITE_8_BIT, DC_ERROR_MSG

See *Input and Output of Image Data* on page 189 of the *PV-WAVE Programmer's Guide* for more information about 8-bit (binary) data.

DC_READ_24_BIT Function

Reads a 24-bit image file.

Usage

status = DC_READ_24_BIT(*filename, imgarr*)

Input Parameters

filename – A string containing the pathname and filename of the 24-bit image file.

Output Parameters

imgarr – The byte array into which the 24-bit image data is read. Must be a 3-dimensional byte array. Either the first or last dimension of the array is 3; see the Discussion section for more details.

Returned Value

status – The value returned by DC_READ_24_BIT; expected values are:

< 0	Indicates an error, such as an invalid filename.
0	Indicates a successful read.

Input Keywords

Org – Organization (in the file) of the 24-bit image data. Allowed values are:

0	Pixel interleaving (RGB triplets).
1	Image interleaving (separate planes).

If not provided, 0 (pixel interleaving) is assumed.

Output Keywords

XSize — The width (size in the X direction) of *imgarr*. The width is computed and returned in *XSize* if *imgarr* is not explicitly dimensioned. *XSize* is returned as an integer.

YSize — The height (size in the Y direction) of *imgarr*. The height is computed and returned in *YSize* if *imgarr* is not explicitly dimensioned. *YSize* is returned as an integer.

Discussion

DC_READ_24_BIT handles many steps that you have to do yourself when using other PV-WAVE functions and procedures. These steps include: 1) opening the file, 2) assigning it a logical unit number (LUN), and 3) closing the file when you are done reading the data.

When choosing the value for the *Org* keyword, be sure to select an organization that matches the file, even if it is the opposite of that used in the variable. In other words, if the data in the file is pixel interleaved, specify *Org=0*, and if the data is image interleaved, specify *Org=1*.

The way the data is read into the variable depends primarily on the dimensions that the variable was given when it was created. Consequently, an image interleaved file can be read into a pixel interleaved variable, and vice versa. So, if you want the data in the variable organized differently than it was organized in the file, predimension the import variable before calling DC_READ_24_BIT. Dimension the variable with a width *w* and a height *h* that matches those shown in the table later in this section.

Dimensionality of the Import Variable

If the dimensions of the byte array *imgarr* are not known, DC_READ_24_BIT makes a "best guess" about the width, height, and depth of the image. It guesses by checking the number of bytes in the file and comparing that number to the number of bytes associated with the following common image sizes:

Image Width	Image Height	Image Depth
640	480	3
640	512	3
128	128	3
256	256	3
512	512	3
1024	1024	3

If no match is found, DC_READ_24_BIT resorts to assuming that the image is square, and returns *XSize* and *YSize* as the square root of the number of bytes in the file, divided by 3.

PV-WAVE uses the following guidelines to dimension *imgarr*:

Interleaving Method	Dimensions of Image Variable
Pixel Interleaving	Dimension *imgarr* as *3* x *w* x *h*, where *w* and *h* are the width and length of the image in pixels.
Image Interleaving	Dimension *imgarr* as *w* x *h* x *3*, where *w* and *h* are the width and length of the image in pixels.

Note You do not need to explicitly dimension *imgarr*, but if your image data is not one of the standard sizes (e.g., 3-by-512-by-512 or 640-by-480-by-3), you will get more predictable results if you dimension *imgarr* yourself.

Example

If the file `harpoon.img` contains a 786432 byte 24-bit image-interleaved image, the function call:

```
status = DC_READ_24_BIT('harpoon.img', $
   H24_image, Org=1, XSize=xdim, YSize=ydim)
```

reads the file `harpoon.img`, creates a 512-by-512-by-3 image-interleaved byte array named `H24_image`, and returns `xdim` and `ydim` as 512.

See Also

DC_WRITE_24_BIT, DC_ERROR_MSG

See *Input and Output of Image Data* on page 189 of the *PV-WAVE Programmer's Guide* for more information about 24-bit (binary) data and for more information about image interleaving options.

DC_READ_TIFF Function

Reads a Tag Image File Format (TIFF) file.

Usage

status = DC_READ_TIFF(*filename, imgarr*)

Input Parameters

filename — A string containing the pathname and filename of the TIFF file.

Output Parameters

imgarr — The PV-WAVE variable into which the TIFF image data is read. May be an array of any dimension and type; *imgarr*'s data type is changed to byte and then *imgarr* is re-dimensioned using information in the TIFF file. Note that variables of type structure are not supported.

Returned Value

status — The value returned by DC_READ_TIFF; expected values are:

< 0	Indicates an error, such as an invalid filename or image number.
0	Indicates a successful read.

Input Keywords

Imgnum – The number of the image to read from the file. If not provided, the first image (image number 0) is read.

Output Keywords

Colormap – The TIFF image colormap. If present, the colormap associated with the TIFF image is returned. *Colormap* is returned as a 2-dimensional array of long integers.

Imagewidth – The TIFF image width. If present, the TIFF image width is returned. *Imagewidth* is returned as a long integer value.

Imagelength – The TIFF image length. If present, the TIFF image length is returned. *Imagelength* is returned as a long integer value.

XResolution – The number of pixels per *ResolutionUnit* in the X direction. If present, retrieves information about the number of X pixels from the TIFF image header. *XResolution* is returned as a floating-point value.

YResolution – The number of pixels per *ResolutionUnit* in the Y direction. If present, retrieves information about the number of Y pixels from the TIFF image header. *YResolution* is returned as a floating-point value.

ResolutionUnit – The type of resolution units specified in the TIFF image header. If present, retrieves unit information from the TIFF image. *ResolutionUnit* is returned as an integer; expected values are:

1	None (no absolute units)
2	Inches
3	Centimeters

BitsPerSample – The number of bits that comprise each sample in the TIFF image is returned; a pixel consists of one or more "samples". *BitsPerSample* is returned as an integer; typical values are 2, 4, and 8.

SamplesPerPixel – The number of samples associated with each pixel in the TIFF image is returned. *SamplesPerSample* is returned as an integer; expected values are:

1	Bilevel, Grayscale, Palette color
3	RGB images

Compression – The compression style used in the TIFF image. *Compression* is returned as an integer; expected values are:

1	None (no compression)
2	CCITT Group 3
5	LZW
32773	PackBits

PhotometricInterpretation – The class of the TIFF image. If present, retrieves photometric information from the TIFF image header. *PhotometricInterpretation* is returned as an integer; expected values are:

0	Bilevel/Grayscale*
1	Bilevel/Grayscale*
2	Full RGB color
3	Palette color
4	Transparency mask†

* If *PhotometricInterpretation=0*, 0 is imaged as white, and *2**BitsPerSample–1* is imaged as black.
If *PhotometricInterpretation=1*, 0 is imaged as black, and *2**BitsPerSample–1* is imaged as white.

† Transparency mask indicates the image is used to define an irregularly shaped region of another image in the same TIFF file. *PhotometricInterpretation=4* is not supported by PV-WAVE.

Note The first four classes of TIFF images are explained in more detail in *TIFF Conformance Levels* on page 192 of the *PV-WAVE Programmer's Guide.*

PlanarConfig – The arrangement of the RGB information. If present, retrieves RGB configuration information from the TIFF image header. *PlanarConfig* is returned as an integer; expected values are:

1	RGB triplets (pixel interleaving)
2	Separate planes (image interleaving)

The methods for interleaving image data are explained more fully in *Image Interleaving* on page 193 of the *PV-WAVE Programmer's Guide.*

Note For more information about the output keywords described in this section, see the Technical Memorandum, *Tag Image File Format Specification, Revision 5.0 (FINAL),* published jointly by Aldus™ Corporation and Microsoft™ Corporation.

Discussion

DC_READ_TIFF enables you to import TIFF images into PV-WAVE. It also handles many steps that you have to do yourself when using other PV-WAVE functions and procedures. These steps include: 1) opening the file, 2) assigning it a logical unit number (LUN), and 3) closing the file when you are done reading the data.

DC_READ_TIFF sets the dimension and type (byte array) of *imgarr* automatically, depending on the width and height of the image. For 24-bit images, the interleaving method (see description of *PlanarConfig* keyword) is considered, as well. PV-WAVE uses the following guidelines to dimension *imgarr*:

Interleaving Method	Dimensions of Image Variable
Pixel (RGB triplets)	Dimension *imgarr* as *3* x *w* x *h*, where *w* and *h* are the width and length of the image in pixels.
Image (separate planes)	Dimension *imgarr* as *w* x *h* x *3*, where *w* and *h* are the width and length of the image in pixels.

The difference between pixel-interleaved and image-interleaved image data is discussed in *Image Interleaving* on page 193 of the *PV-WAVE Programmer's Guide.*

Note Compressed TIFF images are uncompressed before being transferred to the named PV-WAVE variable.

Example 1

The function call:

```
status = DC_READ_TIFF('oxford.tif', oximage)
```

reads the file `oxford.tif` and returns the TIFF image data contained in the first image of that file. The data is transferred to the PV-WAVE variable `oximage`.

Example 2

The function call:

```
status = DC_READ_TIFF('shamu.tif', shamu, $
   Imagewidth=xsz, Imagelength=ysz, $
   PlanarConfig=planar, Photometric=photo)
```

reads a complete description of the first TIFF image in the file `shamu.tif`. The width and length of the image are returned in `xsz` and `ysz`, respectively. *PlanarConfig* and *PhotometricInterpretation* are returned in `planar` and `photo`, respectively.

The fact that the *PlanarConfig* keyword is being returned with the function call suggests that the image in `shamu.tif` is a full-color RGB (24-bit) image. The *PlanarConfig* keyword is used to return the image interleaving method for 24-bit images.

See Also

DC_WRITE_TIFF, DC_ERROR_MSG

See *TIFF Image Data* on page 191 of the *PV-WAVE Programmer's Guide* for more information about TIFF image I/O.

DC_WRITE_FIXED Function

Writes the contents of one or more PV‑WAVE variables (in ASCII fixed format) to a file using a format that you specify.

Usage

status = DC_WRITE_FIXED(*filename, var_list, format*)

Input Parameters

filename – A string containing the pathname and filename of the file where the data will be stored.

var_list – The list of PV‑WAVE variables containing the values to be written. Note that variables of type structure are not supported. An exception to this is the !DT, or date/time, structure. It is possible to transfer date/time data using this routine.

Returned Value

status – The value returned by DC_WRITE_FIXED; expected values are:

< 0	Indicates an error, such as an invalid filename or an I/O error.
0	Indicates a successful write.

Input Keywords

Format – A string containing the C- or FORTRAN-like format statement that will be used to write the data. The format string must contain at least one format code that transfers data; FORTRAN formats must be enclosed in parentheses. If not provided, C format(s) that match the data type(s) of the variables in *var_list* are assumed; for example `%lf` for float, `%i` for integer, and `%s` for string.

Row – A flag that signifies *filename* is to be written as a row-organized file. If neither *Row* nor *Column* is present, *Row* is the default.

Column – A flag that signifies *filename* is to be written as a column-organized file.

Miss_Str – An array of strings that specifies strings that are substituted in the output file (to represent missing data) for each value in *Miss_Vals*. If not provided, no strings are substituted for missing data.

Miss_Vals – An array of integer or floating-point values, each of which corresponds to a string in *Miss_Str*. As PV-WAVE writes the data, it checks for values that match *Miss_Vals*; whenever it encounters one, it substitutes the corresponding value from *Miss_Str*.

Dt_Template – An array of integers indicating the data/time templates that are to be used for interpreting date/time data. Positive numbers refer to date templates; negative numbers refer to time templates. For more details, see DC_WRITE_FREE, *Example 4* on page 218. To see a complete list of date/time templates, see *Transferring Date/Time Data* on page 168 of the *PV-WAVE Programmer's Guide*.

Discussion

DC_WRITE_FIXED is capable of interpreting either FORTRAN- or C-style formats, and is very adept at storing data in a column-oriented manner. Also, DC_WRITE_FIXED handles many steps that you have to do yourself when using other PV-WAVE functions and procedures. These steps include: 1) opening the file, 2) assigning it a logical unit number (LUN), and 3) closing the file when you are done writing the data.

If neither the *Row* or *Column* keywords are provided, the data is stored in rows. If both keywords are used, the *Row* keyword is assumed.

Note This function can be used to write data from date/time structures, but not from any other kind of PV-WAVE structures.

How the Data is Written to the File

As many as 255 variables can be included in the output argument *var_list*. You can use the continuation character ($) to continue the function call onto additional lines, if needed. The entire contents of each variable in *var_list* is written to the specified file. If an error occurs, a nonzero status is returned.

Note Any variable you include in *var_list* must have been previously created; otherwise, an error occurs.

As data is being transferred from multi-dimensional variables, those variables are treated as collections of scalar variables, meaning the first subscript of the export variable varies the fastest. For two-dimensional export variables, this implies that the column index varies faster than the row index. In other words, data transfer is *row major*; it occurs one row at a time. For more details about storing multi-dimensional variables in a column-oriented manner, see *Writing Column-Oriented Data* on page 207.

The format string is processed from left to right. Record terminators and format codes are processed until no variables are left in *var_list* or until an error occurs. In a FORTRAN format string, when a slash record terminator (/) is encountered, a new output record is started.

Format codes that transfer data are matched with the next available variable (or element of a multi-dimensional variable) in the variable list *var_list*. Data is written to the file and formatted according to the format code. If the data in the variable does not agree with the format code, or the format code does not agree with the type of the variable, a type conversion is performed. If no type conversion is possible, an error results and a nonzero *status* is returned.

Once all variables in the variable list have been stored in the file, DC_WRITE_FIXED stops writing data, and returns a status code of zero (0). This is true even if there are format codes in *Format* that did not get used. Even if an error occurs, and *status* is nonzero, the data that has been written successfully (prior to the error) is left intact in the file.

Tip

If an error does occur, view the contents of the file (using an operating system command) to see how much data was transferred. This will enable you to isolate the portion of the variable list in which the error occurred.

If the format string does not contain any format codes that transfer data, an error occurs and a nonzero status is returned. The format codes that PV-WAVE recognizes are listed in *Appendix A, FORTRAN and C Format Strings*, in the *WAVE Programmer's Guide.* If a format code that does not transfer data is encountered, it is processed as discussed in that appendix..

Format Reversion when Writing Data

If the last closing parenthesis of the format string is reached and there are still variables in *var_list* whose contents have not been written to the file, *format reversion* occurs. In format reversion, the current output record is terminated, a new one is started, and format string processing reverts to the first group repeat specification that does not have an explicit repeat count. If the format does not contain a group repeat specification, format processing reverts to the initial opening parenthesis of the format string.

For more information about format reversion and group repeat specifications, see *Appendix A, FORTRAN and C Format Strings*, in the *WAVE Programmer's Guide.*

Missing Data String Substitution while Writing Data

PV-WAVE expects to substitute a string from *Miss_Str* whenever it encounters a value from *Miss_Vals* in the data. Conse-quently, if the number of elements in *Miss_Str* does not match the number of elements in *Miss_Vals*, a nonzero status is returned and no data is written to the file. The maximum number of values permitted in *Miss_Str* and *Miss_Vals* is 10.

Writing Row-Oriented Data

If the *Row* keyword has been provided, each variable in *var_list* is written to the file in its entirety before any data is transferred from the next variable.

If you are interested in an illustration showing what row-oriented data can look like inside a file, see *Row-Oriented ASCII Data Files* on page 146 of the *PV-WAVE Programmer's Guide.*

Writing Column-Oriented Data

The following table shows how PV-WAVE variables of any dimensions are stored in a columnar format:

Table 2-2: Writing Data to a Column-Organized File

Dimensions of Variable	Organization of Saved File
One-dimensional (*1* x *n*)	One value from each variable written to each record (repeated *n* times)
Two-dimensional (*m* columns by *n* rows)	*m* values from each variable written to each record (repeated *n* times)
Three-dimensional (*m* x *n* x *p*)	*m* values from each variable written to each of *n* records (entire process repeated *p* times)
q-dimensional (*m* x *n* x *p* x *q*)	*m* values from each variable written to each of *n* records (above process repeated *p* times) (entire process repeated *q* times)

If you are interested in an illustration demonstrating what column-oriented data can look like inside a file, see *Column-Oriented ASCII Data Files* on page 144 of the *PV-WAVE Programmer's Guide.*

Example 1

If variable sara is a floating-point array with 10 elements all equal to 1.0, `tana` is a floating-point array with 5 elements all equal to 2.0, and `cora` is a floating-point array with 8 elements all equal to 3.0, the function call:

```
status = DC_WRITE_FIXED('outfile.dat', sara, $
   tana, cora, Format="(5(1X, F7.4))")
```

creates `outfile.dat` containing the following values:

```
..1.0000..1.0000..1.0000..1.0000..1.0000
..1.0000..1.0000..1.0000..1.0000..1.0000
..2.0000..2.0000..2.0000..2.0000..2.0000
..3.0000..3.0000..3.0000..3.0000..3.0000
..3.0000..3.0000..3.0000
```

The periods are used to represent blank spaces in the file.

Example 2

If variable `bogus` is a 2-by-4 integer array with values 1 through 4 in the first column and values 5 through 8 in the second column, the following function call:

```
status = DC_WRITE_FIXED('intfile.dat', /Col, $
   bogus, Format='(I5)')
```

replicates that structure in the created file `intfile.dat`, as shown below:

```
....1....5
....2....6
....3....7
....4....8
```

The periods are used to represent blank spaces in the file.

On the other hand, the following function call:

```
status = DC_WRITE_FIXED('intfile.dat', $
   bogus(1,*), Format='(4I5)')
```

with a slightly different format string, results in four values all being written in the same record, using a row orientation:

```
....5....6....7....8
```

Because of the array subscripting notation used in the function call, only the second column of data values is written to the file. Without the "4" inside the parentheses of the format string, each value would have been written on a separate line in the file.

Example 3

If variable `foo` is a floating-point array with 6 elements all equal to 1.0, hoo is a floating-point array with 6 elements all equal to 2.0, doo is a floating-point array with 6 elements all equal to 3.0, and boo is a floating-point array with 6 elements all equal to 4.0, the function call:

```
status = DC_WRITE_FIXED('omni.dat', foo, $
   hoo, doo, boo, Format="%f, %f, %f, %f", $
   /Col)
```

creates an output file `omni.dat` that is organized as shown below:

```
1.0000, 2.0000, 3.0000, 4.0000
1.0000, 2.0000, 3.0000, 4.0000
1.0000, 2.0000, 3.0000, 4.0000
1.0000, 2.0000, 3.0000, 4.0000
1.0000, 2.0000, 3.0000, 4.0000
1.0000, 2.0000, 3.0000, 4.0000
```

The data is arranged in columns. The C format code `"%f, "` causes a comma followed by a space to be inserted after every value written to the file.

Tip An even easier way to write this data is to use another "DC" function, DC_WRITE_FREE. The DC_WRITE_FREE function writes CSV (Comma Separated Values) data by default, or you can use the *Delim* keyword to specify some other delimiter besides the comma.

Example 4

Assume that you have two variables, `float` and `date`, that contain some data values and also some chronological information about when those data values were recorded:

```
date = STR_TO_DT(['10/10/92', '11/11/92', $
   '12/12/92']
float = [1.2, 3.4, 5.6]
```

The STR_TO_DT function creates a date/time variable `date`. For more information on the internal structure of date/time structure variables, see *The PV-WAVE Date/Time Structure* on page 225 of the *PV‑WAVE User's Guide.*

In this example, date/time Template 1 (MM/DD/YY) is used to transfer this data, which means the month, day, and year will be written as adjacent values separated by a slash (/).

If you enter the following PV‑WAVE command:

```
status = DC_WRITE_FIXED("thymus.dat", $
   date, float, /Col, Dt_Template=[1], $
   Format="(A10, 1X, F4.2)")
```

you create a file that looks like this:

```
   10/10/1992 1.20
   11/11/1992 3.40
   12/12/1992 5.60
```

Notice that date data is written into the file `thymus.dat` as a series of strings. In each new output record, Template 1 is used to write the data from `date`, using the A10 character format, and a value from `float` is written, using the F4.2 format.

Note If you have date and time data stored in the same PV‑WAVE variable, the variable must be listed twice in the variable list in order to extract both the date and time data. For more details, see DC_READ_FREE, *Example 4* on page 218.

Example 5

Suppose you have a number of PV-WAVE variables that contain data about recent phone activity. The names of these variables are `date`, `time`, `mins`, `type`, `ext`, `cost`, and `num_called`. The following command writes this information to a file and organizes the values by columns:

```
status = DC_WRITE_FIXED('phonedata.dat', $
   date, time, mins, type, ext, cost, $
   num_called, /Col, $
   Format="%s %s %5.2f %i %i %5.2f %s")
```

Note In this example, `date` and `time` are variables with a data type of string. Because they are not defined as a date/time structure, such as the variable `date` that was part of the previous example, `date` and `time` are not stored using any of PV-WAVE's date or time templates. Thus, there is no need to include the *Dt_Template* keyword as part of the function call.

The result is a file `phonedata.dat` that is organized as shown below:

```
901002 093200  21.40   1    311   5.78   2158597430
901002 093600  51.56   1    379  13.92   2149583711
901002 093700  61.39   2    435  16.58   9137485920
```

The following function call could be used instead of the one shown above if you prefer to use a FORTRAN-style format string:

```
status = DC_WRITE_FIXED('phonedata.dat', $
   date, time, mins, type, ext, cost, $
   num_called, /Col, Format="(A6,1X,A6," +
   "2X,F5.2,4X,I2,4X,I3,2X,F5.2,1X,A12)")
```

Note If you wish to enter a format string similar to the FORTRAN one shown above, try to get the entire format string on the same line. Otherwise, use the string concatenation operator (+), as shown in the above example, to split the format string into two shorter strings.

See Also

DC_WRITE_FREE, DC_READ_FIXED, DC_ERROR_MSG

See *Explicitly Formatted Input and Output* on page 165 of the *PV-WAVE Programmer's Guide* for more information about fixed format I/O in PV-WAVE.

DC_WRITE_FREE Function

Writes the contents of one or more PV-WAVE variables to a file in ASCII free format.

Usage

status = DC_WRITE_FREE(*filename, var_list*)

Input Parameters

filename – A string containing the pathname and filename of the file where the data will be stored.

var_list – The list of PV-WAVE variables containing the values to be written. Note that variables of type structure are not supported. An exception to this is the !DT, or date/time, structure. It is possible to transfer date/time data using this routine.

Returned Value

status – The value returned by DC_WRITE_FREE; expected values are:

< 0	Indicates an error, such as an invalid filename or an I/O error.
0	Indicates a successful write.

Input Keywords

Delim – A single-character string that will be placed between values in the output data file. If you provide an array of strings, only the first string in the array will be used. If not provided, commas are used as delimiters in the file.

Row – A flag that signifies *filename* is to be written as a row-organized file. If neither *Row* nor *Column* is present, *Row* is the default.

Column – A flag that signifies *filename* is to be written as a column-organized file.

Miss_Str – An array of strings that are substituted in the output file (to represent missing data) for each value in *Miss_Vals*. If not provided, no strings are substituted for missing data.

Miss_Vals – An array of integer or floating-point values, each of which corresponds to a string in *Miss_Str*. As PV-WAVE writes the data, it checks for values that match *Miss_Vals*; whenever it encounters one, it substitutes the corresponding value from *Miss_Str*.

Dt_Template – An array of integers indicating the data/time templates that are to be used for interpreting date/time data. Positive numbers refer to date templates; negative numbers refer to time templates. For more details, see *Example 4* on page 218. To see a complete list of date/time templates, see *Transferring Date/Time Data* on page 168 of the *PV-WAVE Programmer's Guide.*

Discussion

DC_WRITE_FREE is very adept at storing data in a column-oriented manner. Also, DC_WRITE_FREE handles many steps that you have to do yourself when using other PV-WAVE functions and procedures. These steps include: 1) opening the file, 2) assigning it a logical unit number (LUN), and 3) closing the file when you are done writing the data.

DC_WRITE_FREE relieves you of the task of composing a format string to describe the organization of the data in the output file. By default, DC_WRITE_FREE generates CSV (Comma Separated Values) files. However, you can override this default by using the *Delim* keyword to provide a different delimiter, if you wish.

If neither the *Row* or *Column* keywords are provided, the data is stored in rows. If both keywords are used, the *Row* keyword is assumed.

Note This function can be used to write data from date/time structures, but not from any other kind of PV-WAVE structures.

How the Data is Written to the File

As many as 255 variables can be included in the output argument *var_list*. You can use the continuation character ($) to continue the function call onto additional lines, if needed. The entire contents of each variable in *var_list* is written to the specified file. If an error occurs, a nonzero status is returned.

Note Any variable you include in *var_list* must have been previously created; otherwise, an error occurs.

The values in the output file are separated with the character specified with the *Delim* keyword. If no *Delim* keyword is provided, a comma delimiter is used by default.

As data is being transferred from multi-dimensional variables, those variables are treated as collections of scalar variables, meaning the first subscript of the export variable varies the fastest. For two-dimensional export variables, this implies that the column index varies faster than the row index. In other words, data transfer is *row major*; it occurs one row at a time. For more details about storing multi-dimensional variables in a column-oriented manner, see *Writing Column-Oriented Data* on page 207.

Once all variables in the variable list have been stored in the file, DC_WRITE_FREE stops writing data, and returns a status code of zero (0). Even if an error occurs, and *status* is nonzero, the data that has been written successfully (prior to the error) is left intact in the file.

Tip If an error does occur, view the contents of the file (using an operating system command) to see how much data was transferred. This will enable you to isolate the portion of the variable list in which the error occurred.

Formatting in the Output File

When writing row-organized files, output lines are formatted to be no more than 80 characters. When writing column-organized files, the output line length depends on the number, type, and dimensions of the variables in *var_list.*

The various PV-WAVE data types are stored using the default formats shown in the following table:

Table 2-3: Output Formats Used by DC_WRITE_FREE

Data Type	Output Formats used by DC_WRITE_FREE
Byte	I4
Integer	I8
Long Integer	I12
Float	G13.6
Double	G16.8
Complex	'(', G13.6, ',', G13.6, ')'
String	A (character data)

Note When writing data of type string, each string is written to the file, flanked with a delimiter on each side. This implies that the strings should not contain delimiter characters if you intend to read the file later with the DC_READ_FREE function.

Writing Row-Oriented Data

If the *Row* keyword has been provided, each variable in *var_list* is written to the file in its entirety before any data is transferred from the next variable.

If you are interested in an illustration showing what row-oriented data can look like inside a file, see *Row-Oriented ASCII Data Files* on page 146 of the *PV-WAVE Programmer's Guide.*

Writing Column-Oriented Files

For more information about how data from multi-dimensional export variables is stored in a columns in the output file, see *Writing Column-Oriented Data* on page 207.

If you are interested in an illustration demonstrating what column-oriented data can look like inside a file, see *Column-Oriented ASCII Data Files* on page 144 of the *PV‑WAVE Programmer's Guide.*

Example 1

If variable `sara` is a floating-point array with 10 elements all equal to 1.0, `tana` is a floating-point array with 5 elements all equal to 2.0, and `cora` is a floating-point array with 8 elements all equal to 3.0, the function call:

```
status = DC_WRITE_FREE('outfile.dat', sara, $
   tana, cora, /Row)
```

creates `outfile.dat` containing the following values:

```
1.0000, 1.0000, 1.0000, 1.0000, 1.0000,
1.0000, 1.0000, 1.0000, 1.0000, 1.0000,
2.0000, 2.0000, 2.0000, 2.0000, 2.0000,
3.0000, 3.0000, 3.0000, 3.0000, 3.0000,
3.0000, 3.0000, 3.0000,
```

A comma is used by default to separate the values in the output file.

Example 2

If variable `bogus` is a 4-by-4 integer array with values 1 through 4 in the first column, values 5 through 8 in the second column, values 9 through 12 in the third column, and values 13 through 16 in the fourth column, the following function call:

```
status = DC_WRITE_FREE('intfile.dat', bogus, $
   Delim=[',','], /Col)
```

creates a file `intfile.dat`, as shown below:

```
1,      5,       9,      13
2,      6,      10,      14
3,      7,      11,      15
4,      8,      12,      16
```

Notice that the organization of values in the output file mimics that of the variable, `bogus`.

On the other hand, the function call:

```
status = DC_WRITE_FREE('intfile.dat', $
   bogus(1,*), /Row, Delim='*')
```

results in the following organization in `intfile.dat`, as shown below:

```
5*       6*       7*       8
```

Because of the array subscripting notation used in the function call, only the second column of data values is written to the file.

Example 3

Suppose you have three PV-WAVE variables that contain data taken from an electronic sensor. The names of these variables are `date`, `time`, and `phase_shift`. `date` and `time` are long integer vectors, and `phase_shift` is a vector of complex (floating-point) values. The function call:

```
status = DC_WRITE_FREE('day539.dat', date, $
   time, phase_shift, Delim='/', /Col)
```

results in a file `day539.dat` that is organized as shown below:

```
921002/   091200/(       -0.139528,        0.983407)
921002/   091205/(       -0.149962,        0.407378)
921002/   091210/(        1.002340,       -0.039187)
921002/   091215/(        1.130523,        0.983482)
921002/   091220/(       -0.947966,        0.171492)
921002/   091225/(        1.275390,        0.789446)
```

The complex numbers are stored as two floating-point values, separated with a comma and enclosed in parentheses.

Example 4

Assume that you have two variables, `float` and `date`, that contain some data values and also some chronological information about when those data values were recorded:

```
date = [10/10/92 05:45:12,
        11/11/92 10:10:51,
        12/12/92 23:03:19]

float = [1.2, 3.4, 5.6]
```

Note: The variable date is shown above as a series of strings, even though it is actually stored in a PV-WAVE date/time structure as a series of integer and floating-point values.

The variable `date` is a PV-WAVE date/time structure, and holds both date and time data. For more information on the internal structure of date/time structure variables, see *The PV-WAVE Date/ Time Structure* on page 225 of the *PV-WAVE User's Guide.*

When you have date and time data stored in the same variable, the variable must be listed twice in the variable list in order to extract both the date and time data. The date/time templates that will be used to transfer this data have the following definitions:

Number	Template Description
1	MM/DD/YY (/ = delimiter)
–1	HH:MM:SS (: = delimiter)

If you enter the following PV-WAVE command:

```
status = DC_WRITE_FREE("thymus.dat", date, $
   float, date, /Col, Dt_Template=[1,-1])
```

you create a file that looks like this:

```
10/10/92 1.2  5:45:12
11/11/92 3.4 10:10:51
12/12/92 5.6 23:03:19
```

Notice that data is written from `date` two different times. In each new output record, Template 1 is used first to write the *date* data from `date`. Next, a value from `float` is written, and finally, Template –1 is used to write the *time* data from `date`.

See Also

DC_READ_FREE, DC_WRITE_FIXED, DC_ERROR_MSG

See *Explicitly Formatted Input and Output* on page 165 of the *PV‑WAVE Programmer's Guide* for more information about free format I/O in PV‑WAVE.

DC_WRITE_8_BIT Function

Writes 8-bit image data to a file.

Usage

status = DC_WRITE_8_BIT(*filename, imgarr*)

Input Parameters

filename – A string containing the pathname and filename of the file where the 8-bit image data is to be stored.

imgarr – The 2-dimensional byte array variable from which the 8-bit image data is transferred.

Returned Value

status – The value returned by DC_WRITE_8_BIT; expected values are:

< 0	Indicates an error, such as an invalid filename.
0	Indicates a successful write.

Keywords

None.

Discussion

DC_WRITE_8_BIT handles many steps that you have to do yourself when using other PV-WAVE functions and procedures. These steps include: 1) opening the file, 2) assigning it a logical unit number (LUN), and 3) closing the file when you are done writing the data.

Note Only one 8-bit image can be stored at a time when using the DC_WRITE_8_BIT function.

If *imgarr* is not a 2-dimensional byte array, DC_WRITE_8_BIT returns an error status and no data is written to the output file.

Example

If `fft_flow` is a 600-by-800 byte array containing image data, the function call:

```
status = DC_WRITE_8_BIT('fft_flow1.img', $
   fft_flow)
```

creates the file `fft_flow1.img` and uses it to store the image data contained in the variable `fft_flow`. The file that is created contains raw binary data, and is easily read by PV-WAVE Point & Click, or with the PV-WAVE function DC_READ_8_BIT.

See Also

DC_READ_8_BIT, DC_WRITE_24_BIT, DC_ERROR_MSG

See *Input and Output of Image Data* on page 189 of the *PV-WAVE Programmer's Guide* for more information about 8-bit (binary) data.

DC_WRITE_24_BIT Function

Writes 24-bit image data to a file.

Usage

status = DC_WRITE_24_BIT(*filename, imgarr*)

Input Parameters

filename — A string containing the pathname and filename of the file where the 24-bit image data is to be stored.

imgarr — The 3-dimensional byte array from which the 24-bit image data is transferred. Either the first or last dimension of *imgarr* must be 3; see the Discussion section for more details.

Returned Value

status — The value returned by DC_WRITE_24_BIT; expected values are:

< 0	Indicates an error, such as an invalid filename.
0	Indicates a successful write.

Input Keywords

Org — Organization of the 24-bit image data. Allowed values are:

0	Pixel interleaving (RGB triplets).
1	Image interleaving (separate planes).

If not provided, 0 (pixel interleaving) is assumed.

Discussion

DC_WRITE_24_BIT handles many steps that you have to do yourself when using other PV-WAVE functions and procedures. These steps include: 1) opening the file, 2) assigning it a logical unit number (LUN), and 3) closing the file when you are done writing the data.

Note Only one 24-bit image can be stored at a time when using the DC_WRITE_24_BIT function.

If *imgarr* is not a 3-dimensional byte array, DC_WRITE_24_BIT returns an error status and no data is written to the output file. Either the first or last dimension of *imgarr* must be equal to 3, as shown in the following table:

Interleaving Method	Dimensions of Image Variable
Pixel (RGB triplets)	*3* x *w* x *h*, where *w* and *h* are the width and length of the image in pixels.
Image (separate planes)	*w* x *h* x *3*, where *w* and *h* are the width and length of the image in pixels.

The difference between pixel-interleaved and image-interleaved data is discussed in *Image Interleaving* on page 193 of the *PV-WAVE Programmer's Guide.*

Example

If `hi_glow` is a 400-by-400-by-3 byte array containing 24-bit image data, the function call:

```
status = DC_WRITE_24_BIT('hi_glow.img', $
   hi_glow, Org=1)
```

creates the file `hi_glow.img` and uses it to store the image data contained in the variable `hi_glow`, using image interleaving. The file that is created contains raw binary data, and is easily read by PV-WAVE Point & Click, or with the PV-WAVE function DC_READ_24_BIT.

See Also

DC_READ_24_BIT, DC_WRITE_8_BIT, DC_ERROR_MSG

See *Input and Output of Image Data* on page 189 of the *PV-WAVE Programmer's Guide* for more information about 24-bit (binary) data.

DC_WRITE_TIFF Function

Writes image data to a file using the Tag Image File Format (TIFF) format.

Usage

status = DC_WRITE_TIFF(*filename, imgarr*)

Input Parameters

filename – A string containing the pathname and filename of the TIFF file.

imgarr – The 2- or 3-dimensional byte array from which the image data is transferred. Note that variables of type structure are not supported.

Returned Value

status – The value returned by DC_WRITE_TIFF; expected values are:

< 0	Indicates an error, such as an invalid filename or image number.
0	Indicates a successful write.

Input Keywords

Palette – The color table to store with the image data if TIFF class P (Palette Color) is specified. *Palette* must be a 3-by-256 array of integers.

Class – TIFF class conformance level; supplied as a string. If not provided, *Class='Bilevel'* is assumed. Valid values are:

```
'Bilevel'
'Grayscale'
'Palette Color'
'RGB Full Color'
```

The strings can be abbreviated to one letter, if you wish.

The four classes of TIFF image conformance are explained in more detail in *TIFF Conformance Levels* on page 192 of the *PV-WAVE Programmer's Guide.*

Compress — A string that signifies the kind of image data compression to use as the data is written to the file (if TIFF class 'B' (Bilevel) is specified). If not provided, no compression is performed. Valid values at this time are:

```
'None'
'PackBits'
```

Discussion

DC_WRITE_TIFF facilitates the exporting of TIFF images from PV-WAVE. It also handles many steps that you have to do yourself when using other PV-WAVE functions and procedures. These steps include: 1) opening the file, 2) assigning it a logical unit number (LUN), and 3) closing the file when you are done writing the data.

Note If *imgarr* is not a 2- or 3-dimensional byte array, DC_WRITE_TIFF returns an error status and no data is written to the output file.

Requirements of the Various TIFF Classes

If TIFF class 'B' (Bilevel) is specified, you can use the *Compress* keyword to create compressed TIFF image files.

If TIFF class 'P' (Palette Color) is specified, you must use the *Palette* keyword to specify a palette array.

If TIFF class 'RGB' (RGB Full Color) is specified, *imgarr* must be a 3-dimensional byte array with the last dimension equal to 3. In other words, *imgarr* must be an image-interleaved image; pixel-interleaved images cannot be stored in a TIFF file when using the DC_WRITE_TIFF function. The difference between pixel-interleaved and image-interleaved data is discussed in *Image Interleaving* on page 193 of the *PV-WAVE Programmer's Guide.*

Example 1

If the variable `maverick` is a 512-by-512 byte array, the function call:

```
status = DC_WRITE_TIFF('mav.tif', maverick, $
   Class='Bi', Compress='Pack')
```

creates the file `mav.tif` and uses it to store the image data contained in the variable `maverick`. The created TIFF file is compressed and conforms to the TIFF 'Bilevel' classification.

Example 2

If the variable `true` is a 400-by-400-by-3 true-color 24-bit image (byte array), the function call:

```
status = DC_WRITE_TIFF('true_c.tif', true, $
   Class='RGB')
```

creates the file `true_c.tif` and uses it to store the RGB color image data contained in the variable `true`; image interleaving is used because the variable is 400-by-400-by-3. The created TIFF file conforms to the TIFF 'RGB Full Color' classification.

See Also

DC_READ_TIFF, DC_ERROR_MSG

See *TIFF Image Data* on page 191 of the *PV-WAVE Programmer's Guide* for more information about TIFF image I/O.

DEFINE_KEY Procedure

Programs a keyboard function key with a string value, or with a specified action.

Usage

DEFINE_KEY, *key* [, *value*]

Input Parameters

key — The name of a function key to be programmed. Must be a scalar string. PV-WAVE maintains an internal list of function key names and the escape sequences they send. Key names are handled differently in UNIX and VMS:

- Under UNIX, if *key* is not already on PV-WAVE's internal list, you must use the *Escape* keyword to specify the escape sequence; otherwise, *key* alone will suffice. Table 2-4 on page 229 describes the standard key definitions; however, available function keys and the escape sequences they send vary from keyboard to keyboard.

  Note that the SETUP_KEYS procedure should be used once at the beginning of the session to enter the keys for the current keyboard.

- Under VMS, key names are defined by the Screen Management utility (SMG). Table 2-5 on page 231 describes some of these keys. For a complete description, see the *VMS RTL Screen Management (SMG$) Manual.*

value — The scalar string that *key* will be programmed with. Afterwards, pressing the programmed key results in *value* being entered as if it had been typed manually at the keyboard. If *value* is not present, and no function is specified for the key with one of the keywords, the key is cleared, and nothing will happen when it is pressed.

Input Keywords

Back_Character – (UNIX only) Programs *key* to move the current cursor position left one character.

Back_Word – (UNIX only) Programs *key* to move the current cursor position left one word.

Delete_Character – (UNIX only) Programs *key* to delete the character to the left of the current cursor.

Delete_Line – (UNIX only) Programs *key* to delete all characters to the left of the current cursor.

Delete_Word – (UNIX only) Programs *key* to delete the word to the left of the current cursor.

End_of_Line – (UNIX only) Programs *key* to move the current cursor to the end of the line.

Enter_Line – (UNIX only) Programs *key* to enter the current line. This is the action normally performed by the <Return> key.

Escape – (UNIX only) Specifies the escape sequence that corresponds to *key*. *Escape* must be a scalar string. See *Defining New UNIX Function Keys* on page 228 for further details.

Forward_Character – (UNIX only) Programs *key* to move the current cursor position right one character.

Forward_Word – (UNIX only) Programs *key* to move the current cursor position right one word.

Insert_Overstrike_Toggle – (UNIX only) Programs *key* to toggle between insert and overstrike mode. When characters are typed into the middle of a line, insert mode causes the trailing characters to be moved to the right to make room for the new ones, while overstrike mode causes the new characters to overwrite the existing ones.

Match_Previous – Programs *key* to prompt the user for a string, and then search the saved command buffer for the most recently issued command that contains that string. If a match is found, the matching command becomes the current command; otherwise the last command entered is used.

Under UNIX, the default match key is the up caret "^" key when pressed in column 1.

Under VMS, the default match key is <PF1>.

Next_Line – (UNIX only) Programs *key* to move forward one command in the saved command buffer and make it the current command.

Noecho – If nonzero, and *value* is present, *Noecho* specifies that when *key* is pressed, its value should be entered without being echoed. This is useful for defining keys that perform actions such as erasing the screen. If *Noecho* is specified, the *Terminate* keyword is assumed to be present and nonzero also.

Previous_Line – (UNIX only) Programs *key* to move back one command in the saved command buffer and make it the current command.

Redraw – (UNIX only) Programs *key* to redraw the current line.

Start_of_Line – (UNIX only) Programs *key* to move the current cursor to the start of the line.

Terminate – If nonzero, and *value* is present, *Terminate* specifies that pressing *key* terminates the current input operation after its value is entered. It acts as an implicit <Return> that is added to the end of *value.*

Defining New UNIX Function Keys

Under UNIX, PV-WAVE can handle arbitrary function keys. Standard UNIX key definitions are listed in Table 2-4.

Table 2-4: UNIX Line Editing Keys

Editing Key	Function
<Control> <A>	Move cursor to start of line.
<Control> <B>	Move cursor left one word.
<Control> <D>	EOF if current line is empty, EOL otherwise.
<Control> <E>	Move to end of line.
<Control> <F>	Move cursor right one word.
<Control> <N>	Move back one line in recall buffer.
<Control> <R>	Redraw current line.
<Control> <U>	Delete from current position to start of line.
<Control> <W>	Delete previous word.
<Backspace>, <Delete>	Delete previous character.
<Escape> <I>	Overstrike/Insert mode toggle.
Escape <Delete>	Delete previous word.
Up Arrow	Move back one line in recall buffer.
Down Arrow	Move forward one line in recall buffer.
Left Arrow	Move left one character.
Right Arrow	Move right one character.
<R13>	Move cursor left one word (Sun keyboard).
<R15>	Move cursor right one word (Sun keyboard).
text	If first character, recall first line containing text; if text is blank, recall previous line.
other characters	Insert the character at the current cursor position.

To add a definition for a function key that is not built into PV-WAVE's default list of recognized keys, use the *Escape* keyword to specify the escape sequence it sends. For example, to add a function key named <HELP> which sends the escape sequence `<Escape> [28~`, use the command:

```
DEFINE_KEY, 'HELP', Escape = '\033[28~'
```

This command adds the <HELP> key to the list of keys understood by PV-WAVE. Since only the key name and escape sequence were specified, pressing the <HELP> key will do nothing. The *value* parameter, or one of the keywords provided to specify command line editing functions, could have been included in the above statement to program it with an action.

Once a key is defined using the *Escape* keyword, it is contained in the internal list of function keys. It can then be subsequently redefined without specifying the escape sequence.

However, if the SETUP_KEYS procedure is used to define the function keys found on the keyboard, it is not necessary to specify the *Escape* keyword. For example, the following statements program the <F2> key on a Sun keyboard to redraw the current line:

```
SETUP_KEYS
DEFINE_KEY, 'F2', /Redraw
```

Note that it is convenient to include commonly used key definitions in a startup file so that they will always be available. For a discussion of startup files, see *WAVE_STARTUP: Using a Startup Command File* on page 48 of the *PV-WAVE User's Guide.*

Defining New VMS Function Keys

Under VMS, PV-WAVE uses the SMG screen-management package, which ensures that PV-WAVE command editing will behave in the standard VMS way. Therefore, it is not possible to use a key SMG does not understand. Some of the most commonly used SMG-defined keys are listed in Table 2-5 below.

Table 2-5: VMS Line Editing Keys

Key Name	Comment
<DELETE>	
<PF1>	Recall most recent command that matches supplied string.
<PF2> – <PF4>	Top row of keypad.
<KP0> – <KP9>	Keypad 0-9 keys.
<ENTER>	Keypad ENTER key.
<MINUS>	Keypad "–" key.
<COMMA>	Keypad ","key.
<PERIOD>	Keypad "." key.
<FIND>	Editing keypad FIND key.
<INSERT_HERE>	Editing keypad INSERT_HERE key.
<REMOVE>	Editing keypad REMOVE key.
<SELECT>	Editing keypad SELECT key.
<PREV_SCREEN>	Editing keypad PREV_SCREEN key.
<NEXT_SCREEN>	Editing keypad NEXT_SCREEN key.

See Also

SETUP_KEYS, SETDEMO

DEFROI Function

Standard Library function that defines an irregular region of interest within an image by using the image display system and the mouse.

Usage

result = DEFROI(*sizex, sizey* [, *xverts, yverts*])

Input Parameters

sizex — The size of the image, in pixels, in the X direction.

sizey — The size of the image, in pixels, in the Y direction.

Output Parameters

xverts — The X coordinates of the vertices enclosing the region.

yverts — The Y coordinates of the vertices enclosing the region.

Returned Value

result — A vector containing the subscripts of the pixels inside the region.

Input Keywords

Noregion — If nonzero, inhibits the return of the pixel subscripts.

Zoom — The zoom factor to be used for displaying the image. If omitted, 1 is assumed.

Xo — The X coordinate of the lower-left corner of the image in the window. Screen device coordinates are used.

Yo — The Y coordinate of the lower-left corner of the image in the window. Screen device coordinates are used.

Discussion

DEFROI lets you interactively select a portion of an image for further processing — simply point with the mouse to the vertices of an irregular polygon containing the region of interest inside the image.

The write mask for the display is set so that only bit 0 may be written. Bit 0 is erased for all pixels and is used to draw the outline of the region. (This may have to be changed to fit the capabilities and procedures of your device.) The common block COLORS is used to obtain the current color table, which is modified and then restored. The color tables are loaded with odd values complemented and even values unchanged.

A message is printed to assist you in selecting the region with the mouse. The POLYFILLV function is used to compute the subscripts within the region.

Example

This example uses DEFROI to define a region of interest within an image. The subscripts of pixels within the region, which are returned by DEFROI, are used to invert the colors within the region of interest. The pixels outside the region are not altered.

```
OPENR, unit, FILEPATH('whirlpool.img', $
   Subdir = 'data'), /Get_Lun
```

Open the whirlpool.img file.

```
a = ASSOC(unit, BYTARR(512, 512))
```

Associate a 512-by-512 byte array with the file unit number of whirlpool.img.

```
g = a(0)
```

Read the galaxy image into the variable g.

```
FREE_LUN, unit
```

Free the file unit number in unit.

```
!Order = 1
```

```
LOADCT, 3
```

Load the red temperature color table. Scale the array containing the image so that the maximum color used is !D.N_Colors.

```
g = BYTSCL(g, Top = !D.N_Colors)
```

Display the image.

```
WINDOW, 0, Xsize = 512, Ysize = 512
TV, g
subs = DEFROI(512, 512)
```

Define a region of interest using DEFROI.

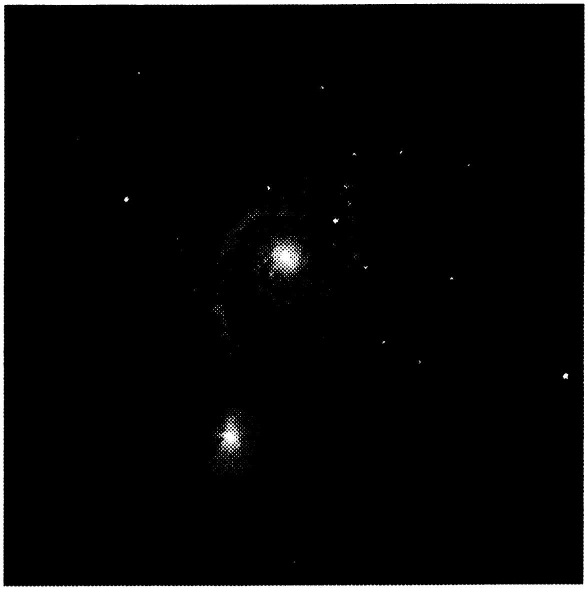


Figure 2-9 Galaxy image with region of interest defined by DEFROI.

```
g(subs) = !D.N_Colors - g(subs)
```

Invert the colors of pixels that lie within the specified region.

```
TV, g
```

Display the resulting image.

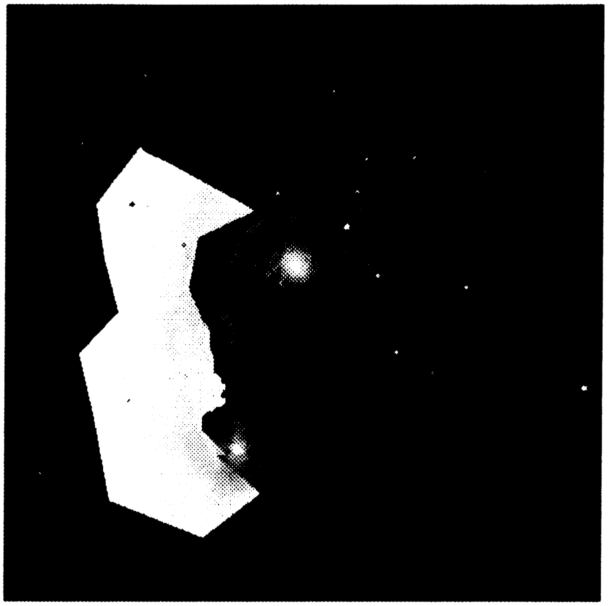


Figure 2-10 Galaxy image with region of interest inverted.

See Also

POLYFILLV

DEFSYSV Procedure

Creates a new system variable initialized to the specified value.

Usage

DEFSYSV, *name, value* [, *read_only*]

Input Parameters

name – A scalar string containing the name of the system variable to be created. All system variables must begin with the ! character.

value – An expression from which the type, structure, and initial value of the new system variable is taken. May be a scalar, array, or structure.

read_only – If present and nonzero, causes the resulting system variable to be read-only. Otherwise, the value for *name* may be modified.

Keywords

None.

Discussion

System variables can be defined at the main program level only. They cannot be defined from within a procedure or function.

Example

This example uses procedure DEFSYSV to create read-only system variables to hold Euler's constant *e* which is the base of the natural logarithm, in both single-precision and double-precision forms.

```
DEFSYSV, '!e', 2.71828, 1
```

Create the single-precision system variable containing e.

```
DEFSYSV, '!de', 2.718218D, 1
```

Create the double-precision system variable containing e.

```
INFO, /System_Variables
```

Use the INFO procedure to display all system variables.

```
.
.
.
!DE = 2.7182180
.
.
.
!E = 2.71828
.
.
.
```

See Also

ADDSYSVAR

DELETE_SYMBOL Procedure

(VMS Only) Deletes a DCL (Digital Command Language) interpreter symbol from the current process.

Usage

DELETE_SYMBOL, *name*

Input Parameters

name – A scalar string containing the name of the symbol to be deleted.

Input Keywords

Type – Indicates the VMS table from which *name* will be deleted:

1 Specifies the local symbol table (the default).

2 Specifies the global symbol table.

Example

```
DCL COMMAND LINE> my_sym :== $dev$:[mydir]my.-
   exe
DCL COMMAND LINE> wave
. . .
WAVE> DELETE_SYMBOL, 'my_sym', Type=2
```

See Also

DELLOG, GET_SYMBOL, SET_SYMBOL, SETLOG, TRNLOG

DELFUNC Procedure

Deletes one or more compiled functions from memory.

Usage

DELFUNC, *function*$_1$,..., *function*$_n$

Input Parameters

function$_i$ – A string containing the name of a compiled function to be deleted.

Keywords

All – When present and nonzero, deletes all currently compiled functions. When this keyword is used, all other parameters are ignored.

Discussion

Use this procedure to free the memory taken by compiled functions. You can obtain a list of compiled functions by entering: `INFO, /Routines`.

Example

```
INFO, /Routines
   Saved Procedures:
   LOADCT table_number "SILENT"
   Saved Functions:
   DIST n
   FILEPATH filename "SUBDIRECTORY"
```

```
DELFUNC, "Filepath", "Dist"
```

Deletes the compiled FILEPATH and DIST functions from memory.

See Also

DELSTRUCT, DELPROC, DELVAR

DELLOG Procedure

(VMS Only) Deletes a logical name.

Usage

DELLOG, *logname*

Input Parameters

logname – A scalar string containing the name of the logical to be deleted.

Input Keywords

Table – A scalar string giving the name of the logical table from which to delete *logname*. If *Table* is not specified, the system `LNM$PROCESS_TABLE` is used.

See Also

DELETE_SYMBOL, GET_SYMBOL, SET_SYMBOL, SETLOG, TRNLOG

DELPROC Procedure

Deletes one or more compiled procedures from memory.

Usage

DELPROC, *procedure*$_1$,..., *procedure*$_n$

Input Parameters

procedure$_i$ — A string containing the name of a compiled procedure to be deleted.

Keywords

All — When present and nonzero, deletes all currently compiled procedures. When this keyword is used, all other parameters are ignored.

Discussion

Use this procedure to free the memory taken by compiled procedures. You can obtain a list of compiled procedures by entering: `INFO, /Routines`.

Example

```
INFO, /Routines
   Saved Procedures:
   LOADCT table_number "SILENT"
   Saved Functions:
   DIST n
   FILEPATH filename "SUBDIRECTORY"
```

```
DELPROC, "Loadct"
```

Deletes the compiled LOADCT procedure from memory.

See Also

DELSTRUCT, DELFUNC, DELVAR

DELSTRUCT Procedure

Deletes one or more named structure definitions from memory.

Usage

DELSTRUCT, {$structure_1$} ,..., {$structure_n$}

Input Parameters

***structure**$_i$* – The name of the structure definition to be deleted. The name can be specified as {*structure*}, "*structure*", or *x*, where *x* is a variable of type structure.

Input Keywords

Rename – If present and nonzero, this keyword causes the structure definition to be re-named. DELSTRUCT cannot delete a structure definition if it is currently being used (referenced) by a variable, common block, or other structure definition. If a structure is being used and /*Rename* is given, then the structure definition will be renamed. If the structure is not being used, it will be deleted.

Discussion

DELSTRUCT is useful for freeing memory that is currently taken by unused structure definitions. In addition, this procedure can be used if you need to correct an existing structure definition. To do this, delete the incorrect definition and then create a new, correct structure definition.

If the structure definition is not currently referenced by any variables, other structure definitions, or common blocks, then the structure is deleted. If any references to *structure* exist, then, by default, you receive an error message and the structure is not deleted. The *Rename* keyword overrides this default, and renames the existing structure so that the structure name can be reused. When the *Rename* keyword is used, the original variables remain valid (continue to reference the renamed structure definition); however, no memory is freed.

Use the STRUCTREF function to determine if a structure is currently referenced by any variables, common blocks, or other structure definitions.

Tip You cannot delete structure definitions that are system structure definitions, such as !Axis and !Plot, or any structures that begin with !. Therefore, if you want to create a new structure that cannot be deleted, begin its name with !.

Example

```
WAVE> x = {struct1, a:float(0)}
```

The user changes his or her mind about what type x.a should be.

```
WAVE> DELVAR, x
WAVE> DELSTRUCT, {struct1}
WAVE> x = {struct1, a:double(0)}
```

See Also

STRUCTREF, DELPROC, DELFUNC, DELVAR

For more information on structures, see Chapter 6, *Working with Structures*, in the *PV-WAVE Programmer's Guide*.

DELVAR Procedure

Deletes variables from the main program level.

Usage

DELVAR, v_1, ... ,v_n

Input Parameters

v_i – One or more named variables to be deleted.

Keywords

None.

Discussion

The following restrictions on the use of DELVAR apply:

- DELVAR may only be called from the main program level.
- Each time DELVAR is called, the main program is erased. Variables that are not deleted remain unchanged.
- DELVAR forces the end of the current procedure.

Note DELVAR does not free the memory used by the variable to the operating system. To release memory to the operating system, you must exit PV-WAVE.

Example

This example creates three variables of differing type and structure, then deletes them using DELVAR.

```
a = FINDGEN(3)
```

Create a single-precision, floating-point vector, a.

```
b = {structb, field1:1.0, field2:[5, 6, 7], $
   field3:"pv-wave"}
```

Create an anonymous structure, b.

```
c = 6L
```

Create a longword scalar, c.

```
INFO, a, b, c
```

```
A FLOAT = Array(3)
B STRUCT = -> STRUCTB Array(1)
C LONG = 6
```

```
DELVAR, a, c
```

Delete variables a and c.

```
INFO, a, b, c
```

```
A UNDEFINED = <Undefined>
B STRUCT = -> STRUCTB Array(1)
C UNDEFINED = <Undefined>
```

```
DELVAR, b
```

Delete variable b.

```
INFO, a, b, c
```

```
A UNDEFINED = <Undefined>
B UNDEFINED = <Undefined>
C UNDEFINED = <Undefined>
```

See Also

DELFUNC, DELPROC, DELSTRUCT

For more information on releasing memory to the operating system, see *Running Out of Virtual Memory?* on page 284 of the *PV-WAVE Programmer's Guide*.

DERIV Function

Standard Library function that calculates the first derivative of a function in *x* and *y*.

Usage

result = DERIV([*x*,] *y*)

Input Parameters

x — The vector of X (independent) coordinates of the data (i.e., the variable with respect to which the function should be differentiated). Must be a one-dimensional array (a vector).

y — The vector of Y (dependent) coordinates at which the derivative of function *f* is evaluated. Must be a one-dimensional array (a vector).

Returned Value

result — The first derivative of the vector *y*, with respect to the independent variable *x*. The result has the same size as *y*.

Keywords

None.

Discussion

The numerical differentiation algorithm for DERIV uses a three-point Lagrangian interpolation.

The vector of X coordinates, *x*, is optional. The conditions set on this vector are given below:

- If you specify *x*, then both *x* and *y* must be one-dimensional and have the same number of elements. Selecting this option allows you to define the spacing along the X axis, for the case where the independent data is not monotonically increasing.

- If you don't specify *x*, then it is automatically provided with even spacing, using a unit of one, along the X axis. (In other words, x(i) = i, where i = 0, 1, 2, 3, ... n.)

Example 1

```
x = FINDGEN(10)
xx = x^2
d = DERIV(xx)
PRINT, d
PLOT, xx
OPLOT, d, Linestyle=2
```

Example 2

```
x = FINDGEN(100) * 10 * !Dtor
```

Create an array that contains values 0, 10, 20 ... and multiply these by !Dtor (which equals 0.0174533) to convert the values from degrees to radians.

```
sin_x = SIN(x)
d_sin_x = DERIV(x, sin_x)
PLOT, sin_x
OPLOT, d_sin_x, Linestyle=2
```

See Also

For an example of the three-point Lagrangian interpolation used in DERIV, see the *Introduction to Numerical Analysis* by F. B. Hildebrand, Dover Publishing, New York, 1987.

DETERM Function

Standard Library function that calculates the determinant of a square, two-dimensional input variable.

Usage

result = DETERM(*array*)

Input Parameters

array – An array with two equal dimensions. Can be any data type except string.

Returned Value

result – The determinant of the square matrix of *array*. The result is a scalar value, of either single- or double-precision floating-point data type.

Keywords

None.

Discussion

Determinants can be used to evaluate systems of linear equations.

Example

```
a = INTARR(4,4)
FOR i=0,3 DO a(i,*)=[1,i+2,(i+2)^2,(i+2)^3]
PRINT, a
PRINT, DETERM(a)
   12.0000
```

DEVICE Procedure

Provides device-dependent control over the current graphics device (as specified by the SET_PLOT procedure).

Usage

DEVICE

Parameters

None.

Keywords

Each type of device uses its own unique set of keywords. For a description of these keywords, see Appendix A, *Output Devices and Window Systems*, in the *PV-WAVE User's Guide*.

Discussion

The PV-WAVE graphics procedures and functions are device-independent. This means that PV-WAVE presents you with a consistent interface to all devices.

However, most devices have extra abilities that are not directly available through this interface. Use DEVICE with the appropriate keywords to control these additional capabilities.

See Also

!D, SET_PLOT

DIGITAL_FILTER Function

Standard Library function that constructs finite impulse response digital filters for signal processing.

Usage

result = DIGITAL_FILTER(*flow, fhigh, gibbs, nterm*)

Input Parameters

flow – The value of the lower frequency of the filter, expressed as a fraction of the Nyquist frequency. Must be between 0 and 1.

fhigh – The value of the upper frequency of the filter, expressed as a fraction of the Nyquist frequency. Must be between 0 and 1.

gibbs – The size of the Gibbs Phenomenon variations. Expressed in units of –db (decibels).

nterm – The number of terms in the filter formula used. Determines the order of the filter.

Returned Value

result – The coefficients of a convolution mask to be used in the filtering of digital signals.

Keywords

None.

Discussion

The coefficients returned by DIGITAL_FILTER form the convolution mask or kernel that can be used with the CONVOL function to apply the filter to a signal. The size of this vector is equal to:

$$(2 * nterm) - 1$$

Highpass, lowpass, bandpass, and bandstop filters can be constructed with DIGITAL_FILTER. Use the following values for *fhigh* and *flow* to specify the type of filter you want to obtain:

Desired Effect	**Value**
No filtering	flow = 0, fhigh = 1
Lowpass filter	flow = 0, 0 < fhigh < 1
Highpass filter	0 < flow < 1, fhigh = 1
Bandpass filter	0 < flow < fhigh < 1
Bandstop filter	0 < fhigh < flow < 1

These non-recursive filters require evenly spaced data points. Frequencies are expressed in terms of the Nyquist frequency, *1/2T,* where *T* is the time elapsed between data samples.

The Gibbs Phenomenon variations are oscillations which result from the abrupt truncation of the infinite FFT series. Setting the *gibbs* parameter either too high or too low may yield unacceptable results.

Tip A value of 50 for *gibbs* is a good choice for most filters.

Sample Usage

DIGITAL_FILTER is used extensively in image and signal processing applications to build image or signal filters. It provides a convenient way of creating convolution kernels (containing the filter coefficients) — all you need do is specify the desired filter with respect to the high and low cutoff frequencies, the Gibb's variations, and the number of terms. You can then use the constructed kernels with the CONVOL function to perform the actual filtering operation upon a signal or image.

To evaluate the coefficients of a digital filter and then apply them to a signal, use the following sequence of equations:

Coeff = DIGITAL_FILTER(*flow, fhigh, gibbs, nterm*)

Filtered_Signal = CONVOL(input_signal, coeff)

The end result is an image or signal that has certain frequencies or bands of frequencies filtered out of it. For example, an electrical engineer may want to filter out high frequency harmonics or low frequency flutter from a signal. This can easily be achieved by using the high and low pass filters constructed with DIGITAL_FILTER as the coefficients in the CONVOL function.

Note Two or more filters created by DIGITAL_FILTER can be combined by addition, subtraction, or averaging to create multiple filtering effects with one filter.

Example 1

A digital signal processing example follows:

```
av_temp = FLTARR(140)
OPENR, unit, !Data_dir + 'example_air_q.dat',$
   /Get_lun
READF, unit, av_temp, Format='(5X,F9.4)'
```

Read the average temperature field from the air quality test dataset.

```
FREE_LUN, unit
```

```
PLOT, av_temp
```

Display the original data.

```
filter = DIGITAL_FILTER(0.0, 0.1, 50, 10)
```

Create the convolution kernel for a lowpass filter.

```
filt_temp = CONVOL(av_temp, filter)
```

Filter the data by convolving it with the kernel.

```
OPLOT, filt_temp, Linestyle=2
```

Display the filtered data using a dashed line.

Example 2

An image processing example follows:

```
mandril = BYTARR(512,512)
OPENR, unit, !Data_dir + 'mandril.img',$
   /Get_lun
READU, unit, mandril
```

Read the mandril demo image.

```
FREE_LUN, unit
```

```
WINDOW, XSize=512, YSize=512
TV, mandril
```

Display the original image.

```
mandril = FLOAT(mandril)
```

Convert the byte data to floating-point for filtering.

```
filter = DIGITAL_FILTER(0.0, 0.1, 50, 10)
```

Create the convolution kernel for a lowpass filter.

```
filt_image = CONVOL(mandril, filter)
```

Filter the image by convolving it with the kernel.

```
TV, filt_image
```

Display the filtered image.

See Also

CONVOL

DIGITAL_FILTER is adapted from the article "Digital Filters," by Robert Walraven, in *Proceedings of the Digital Equipment User's Society*, Fall 1984, Department of Applied Science, University of California, Davis, CA 95616.

DILATE Function

Implements the morphologic dilation operator for shape processing.

Usage

result = DILATE(*image, structure* [, x_0, y_0])

Input Parameters

image – The array to be dilated.

structure – The structuring element. May be a one- or two-dimensional array. Elements are interpreted as binary (values are either zero or nonzero), unless the *Gray* keyword is used.

x_0 – The X coordinates of *structure*'s origin.

y_0 – The Y coordinates of *structure*'s origin.

Returned Value

result – The dilated image.

Input Keywords

Gray – A flag which, if present, indicates that gray scale, rather than binary dilation, is to be used.

Values – An array providing the values of the structuring element. Must have the same dimensions and number of elements as *structure.*

Discussion

If *image* is not of the byte type, PV-WAVE makes a temporary byte copy of *image* before using it for the processing.

The optional parameters x_0 and y_0 specify the row and column coordinates of the structuring element's origin. If omitted, the origin is set to the center, ($\lfloor N_x / 2 \rfloor$, $\lfloor N_y / 2 \rfloor$), where N_x and N_y are the dimensions of the structuring element array. However, the origin need not be within the structuring element.

Nonzero elements of the *structure* parameter determine the shape of the structuring element (neighborhood).

Note If the *Values* keyword is not used, all elements of the structuring element are 0, yielding the neighborhood maximum operator.

You can choose whether you want to use gray scale or binary dilation:

- If you select binary dilation type, the image is considered to be a binary image with all nonzero pixels considered as 1. (You will automatically select binary dilation if you don't use either the *Gray* or *Values* keyword.)
- If you select gray scale dilation type, each pixel of the result is the maximum of the sum of the corresponding elements of *values* overlaid with *image*. (You will automatically select gray scale dilation if you use either the *Gray* or *Values* keyword.)

Background Information

The DILATE function implements the morphologic dilation operator on both binary and gray scale images. Mathematical morphology provides an approach to the processing of digital images on the basis of shape. This approach is summarized below.

DILATE returns the dilation of *image* by the structuring element, *structure*. This operation is also commonly known as filling, expanding, or growing. It can be used to fill holes that are equal in size or smaller than the structuring element, or to grow features contained within an image. The result is an image that contains items that may touch each other and become one. Sharp-edged items and harsh angles typically become dull as they expand and grow.

Note Dilation can be used to change the morphological structure of objects or features in an image to see what would happen if they were to actually expand over time.

Used with gray scale images, which are always converted to a byte type, the DILATE function is accomplished by taking the maximum of a set of sums. It may be conveniently used to implement the neighborhood maximum operator, with the shape of the neighborhood given by the structuring element.

Used with binary images, where each pixel is either 1 or 0, dilation is similar to convolution. On each pixel of the image, the origin of the structuring element is overlaid. If the image pixel is nonzero, each pixel of the structuring element is added to the result using the logical OR operator.

Letting $A \oplus B$ represent the dilation of an image A by structuring element B, dilation may be defined as:

$$C = A \oplus B = \bigcup_{b \in B} (A)_b$$

where $(A)_b$ represents the translation of A by b. Intuitively, for each nonzero element b_{ij} of B, A is translated by i,j and summed into C using the OR operator.

Openings and Closings

The *opening* of image B by structuring element K is defined as:

$$(B \, \theta K) \oplus K$$

The *closing* of image B by K is defined as:

$$(B \oplus K) \, \theta K$$

where the erosion operator is denoted by θ and is implemented by the ERODE function.

As stated by Haralick *et al*:

"The result of iteratively applied dilations and erosions is an elimination of specific image detail smaller than the structuring element without the global geometric distortion of unsuppressed features. For example, opening an image with a disk structuring element smooths the contour, breaks narrow isthmuses, and eliminates small islands and sharp peaks or capes.

Closing an image with a disk structuring element smooths the contours, fuses narrow breaks and long thin gulfs, eliminates small holes, and fills gaps on the contours."

Example 1

In the example below, the origin of the structuring element is at (0,0):

```
0100            0110
0100            0110
0110 ⊕ 11 =     0111
1000            1100
0000            0000
```

Example 2

Here is what an aerial image looks like before and after applying the DILATE function three different times. For this example, the following parameters were used each time:

```
img = DILATE(aerial_img, struct, /Gray)
```

where `struct` has a value of [1 0 1].

Because the DILATE function was applied to the image three times, the "blurring" is more pronounced than it would have been with only one dilation.

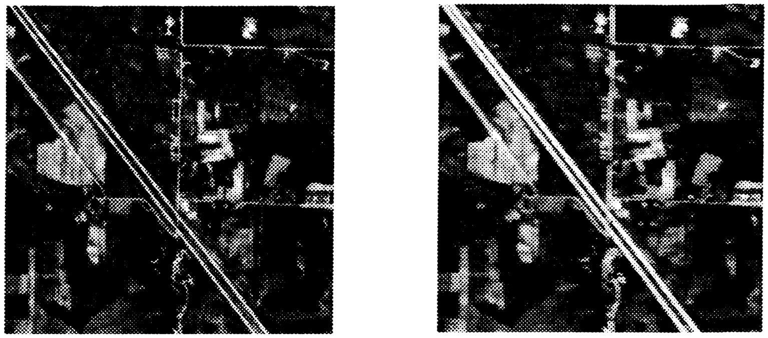


Figure 2-11 The DILATE function has been used to fuse the visual elements of this 512-by-512 aerial image.

See Also

ERODE

For details on the approach used in the DILATE function, refer to the source document: Haralick, Sternberg, and Zhuang, "Image Analysis Using Mathematical Morphology," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. PAMI-9, No. 4, pp. 532-550, July 1987.

DINDGEN Function

Returns a double-precision floating-point array with the specified dimensions.

Usage

result = DINDGEN(*dim*$_1$, ..., *dim*$_n$)

Input Parameters

dim$_i$ — The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result — An initialized double-precision, floating-point array. If the resulting array is treated as a one-dimensional array, then its initialization is given by the following:

$$array\,(i) = \text{DOUBLE}\,(i),\ \text{for}\ i = 0, 1, \ldots, \left(\prod_{j=1}^{n} D_j - 1\right)$$

Keywords

None.

Example

This example creates a 4-by-2 double-precision, floating-point array.

```
a = DINDGEN(4, 2)
```

Create double-precision, floating-point array.

```
INFO, a
A          DOUBLE        = array(4, 2)

PRINT, a
0.0000000   1.0000000   2.0000000   3.0000000
4.0000000   5.0000000   6.0000000   7.0000000
```

See Also

BINDGEN, CINDGEN, FINDGEN, INDGEN, LINDGEN, SINDGEN, DBLARR

DIST Function

Standard Library function that generates a square array in which each element equals the euclidean distance from the nearest corner.

Usage

result = DIST(*n*)

Input Parameters

n – The size of the resulting array.

Returned Value

result – The resulting floating-point array.

Keywords

None.

Discussion

DIST generates a square array in which each element is proportional to its frequency. A three-dimensional plot of this function displays a surface where each quadrant is a curved quadrilateral forming a common cusp at the center.

The result of the DIST function is an *n*-by-*n* single-precision floating-point array, as defined by:

$$result(i,j) = \sqrt{F(i)^2 + F(j)^2}$$

where

$$F(x) = x \text{ if } 0 \le x \le n/2$$

or

$$F(x) = n - x \text{ if } x > n/2$$

The DIST function is particularly useful for creating arrays that can be used for frequency domain filtering in image and signal processing applications.

Tip DIST is an excellent choice when you need a two-dimensional array of any size for a fast test display.

Example 1

```
mandril = BYTARR(512,512)
OPENR, unit, !Data_dir + 'mandril.img', $
   /Get_lun
READU, unit, mandril
FREE_LUN, unit
```

Read the mandril demo image.

```
WINDOW, XSize=512, YSize=512
TV, mandril
```

Display the original image.

```
d = DIST(512)
```

Use the DIST function to create a frequency image of the same size as the mandril demo image.

```
n = 1.0
d0 = 10.0
```

Set n, the order (steepness) of the Butterworth filter to use, and d0, the cutoff frequency.

```
filter = 1.0 / (1.0 + (d/d0)^(2.0 * n))
```

Create a Butterworth low-pass filter to be applied to the image. (For other common filters that could be substituted here, see the reference listed in the See Also section below.)

```
filt_image = FFT(FFT(mandril, -1) * filter, 1)
```

Filter the image by transforming it to the frequency domain, multiplying by the filter, and then transforming back to the spatial domain. (Note that this operation may take a while).

```
TVSCL, filt_image
```

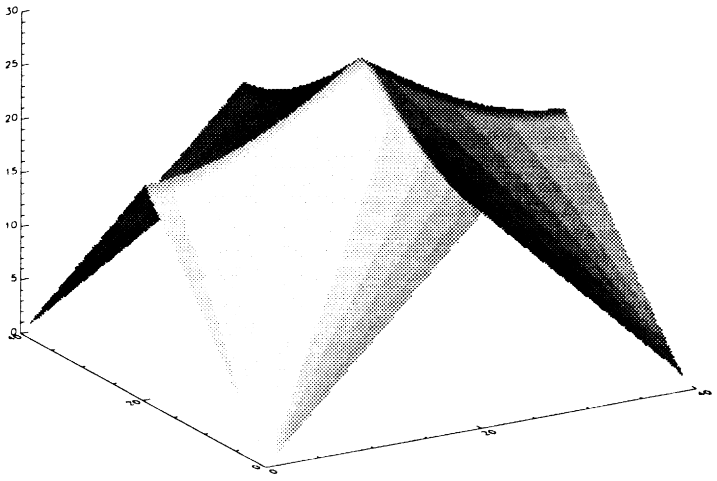
Display the resulting image.

Example 2

Use these commands:

```
testarr = DIST(40)
CONTOUR, testarr
SURFACE, testarr
LOADCT, 7
SHADE_SURF, testarr
testimg = DIST(200)
TVSCL, testimg
```

to create the following surface of an array:



See Also

For more information, see *Frequency Domain Techniques* on page 162 of the *PV-WAVE User's Guide.*

DOC_LIBRARY Procedure

Standard Library procedure that extracts header documentation for user-written PV-WAVE procedures and functions.

Usage

DOC_LIBRARY [, *name*]

Input Parameters

name – A string containing the name of the user-written module for which documentation is desired. The search for the file follows the current path in the system variable !Path.

Input Keywords

Directory – (UNIX only) The name of the directory to search. If this keyword is omitted, the current directory and !Path are used.

File – (VMS only) If present and nonzero, sends the output to the file `userlib.doc` in the current directory.

Multi – (UNIX only) A flag that allows for the printing of more than one file. To do this, *Multi* must be nonzero and the named file must exist in more than one directory in the path.

Path – (VMS only) The directory/library search path. It has the same format and semantics as the system variable !Path. If this keyword is omitted, !Path is used.

Print – A flag to direct the output:

- A value of 1 specifies the output from the procedure is to be sent to the default printer.
- A string value specifies a command to redirect the standard output.
- If the *Print* keyword is not used, documentation is sent to the standard output.

Discussion

The first line of the header documentation must begin with the characters ; + and the last line of the header documentation must begin with the characters ; –. DOC_LIBRARY extracts all the information between the + and – characters. (Each line of the header must begin with the semicolon character to denote a comment line in PV-WAVE.)

DOC_LIBRARY is a useful tool for finding out what is available in the undocumented Users' Library. This procedure can be used to search each routine in the Users' Library and extract all the text that is bracketed by the + and the – characters. This includes the routine's name, purpose, category, calling sequence, inputs, outputs, and modification history.

DOC_LIBRARY checks to see what operating system you are using, and then calls the appropriate version DOC_LIB_UNIX or DOC_LIB_VMS.

Keywords allow you to have the output sent to a printer or displayed on the screen. If the procedure is called without keywords, you are prompted for specific information about the search.

When creating your own PV-WAVE routines, it is helpful to include a ; + as the second line in the file and a ; – as the last informational line so that DOC_LIBRARY can then be used to create documentation for the routine. An example of a file set up to use DOC_LIBRARY in this way is shown below. (All the information shown in bold will be extracted by DOC_LIBRARY.)

```
FUNCTION COSINES, x, m
;+
; NAME:
; COSINES
; PURPOSE:
;  Example of a function to be used by SVDFIT.
   Returns COS(i*COS(x(j)).
; CATEGORY:
;  Curve fitting.
; CALLING SEQUENCE:
```

```
;  r = COSINES(x, m)
; INPUTS:
;  x = vector of data values. n elements.
;  m = order, or number of terms.
; OUTPUTS:
;  Function result = (n,m) array,
;  where n is the number of points in x,
;  and m is the order. r(i,j) = COS(j * x(i))
; MODIFICATION HISTORY:
;  DMS, Nov, 1987.
;-
ON_ERROR, 2
;Return to caller if an error occurs.
RETURN, COS(x # FINDGEN(m))
;Couldn't be much simpler.
END
```

UNIX Examples

```
DOC_LIBRARY, 'adjct'
```

On the screen, display the header for the adjct.pro procedure using the default search path.

```
DOC_LIBRARY, 'adjct', $
   Print='cat > adjct_header'
```

Print the header for adjct.pro to the file adjct_header.

```
DOC_LIBRARY, '*',directory= $
   '/usr/local/pvi/wave/lib/std', $
   Print='cat > user_lib_headers'
```

Print the headers for all the files located in the Users' Library.

VMS Examples

```
DOC_LIBRARY, 'adjct'
```

On the screen, display the header for the adjct.pro procedure using the default search path.

```
DOC_LIBRARY, 'adjct', /File
```

Print the header for adjct.pro to the file userlib.doc.

See Also

INFO, !Path

DOUBLE Function

Converts an expression to double-precision floating-point data type.

Extracts data from an expression and places it in a double-precision floating-point scalar or array.

Usage

result = DOUBLE(*expr*)

This form is used to convert data.

result = DOUBLE(*expr, offset,* dim_1 [, ..., dim_n])

This form is used to extract data.

Input Parameters

expr – The expression to be converted, or from which to extract data.

offset – (Used to extract data only.) The offset, in bytes, from the beginning of *expr* to where the extraction is to begin.

dim_i – (Used to extract data only.) The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result – (For data conversion.) A copy of *expr* converted to double-precision floating-point data type. If no dim_i parameters are specified, *result* has the same structure as *expr*.

(For data extraction.) If *offset* is used, DOUBLE does not convert *result*, but allows fields of data extracted from *expr* to be treated as double-precision floating-point data.

Keywords

None.

Example

In this example, DOUBLE is used in two ways. First, DOUBLE is used to convert an integer array to double precision, floating point. Next, DOUBLE is used to extract a subarray from the double precision array created in the first step.

```
a = INDGEN(6)
PRINT, a
 0   1   2   3   4   5
```

Create an integer vector of length 6 that is initialized to the a = INDGEN(6)value of its one-dimensional subscript.

```
b = DOUBLE(a)
```

Convert a to double precision, floating point.

```
INFO, b
B           DOUBLE           = Array(6)
PRINT, b
0.0000000 1.0000000 2.0000000 3.0000000
4.0000000 5.0000000
```

```
c = DOUBLE(b, 16, 2, 2)
```

Extract the last four elements of b, and place them in a 2-by-2 double-precision, floating-point array.

```
INFO, c
C            DOUBLE      = Array(2, 2)

PRINT, c
2.0000000  3.0000000
4.0000000  5.0000000
```

Note If you want to place the double-precision value of a constant into a PV-WAVE variable, it is more efficient to use the d or D constant notation rather than the double function. For example:

```
x = .0705230784D
```

See Also

BYTE, COMPLEX, FIX, FLOAT, LONG, DBLARR

For more information on using this function to extract data, see *Extracting Fields* on page 37 of the *PV-WAVE Programmer's Guide*.

DROP_EXEC_ON_SELECT Procedure

Drops a single item from the EXEC_ON_SELECT list.

Usage

DROP_EXEC_ON_SELECT, *lun*

Input Parameters

lun – Logical unit number.

Description

A logical unit number and associated command is dropped from the EXEC_ON_SELECT list. This procedure is designed to be called from an EXEC_ON_SELECT callback procedure. When the logical unit number and associated command are dropped from the EXEC_ON_SELECT list, the EXEC_ON_SELECT procedure returns to the calling routine.

See Also

SELECT_READ_LUN, EXEC_ON_SELECT, ADD_EXEC_ON_SELECT

DT_ADD Function

Increment the values in a Date/Time variable by a specified amount.

Usage

result = DT_ADD(*dt_var*)

Input Parameters

dt_var— The original PV-WAVE Date/Time variable or array of variables.

Returned Value

result – A PV-WAVE Date/Time variable incremented by the specified amount.

Input Keywords

Compress – If present and nonzero, excludes predefined weekends and holidays from the result. The default is no compression (0).

Output Keywords

Year – Specifies an offset value in years.

Month – Specifies an offset value in months.

Day – Specifies an offset value in days.

Hour – Specifies an offset value in hours.

Minute – Specifies an offset value in minutes.

Second – Specifies an offset value in seconds.

Note Only one keyword can be specified at a time. You cannot, for example, specify both years and months in a single DT_ADD call. But if you need to add, for example, one day and one hour, you can simply add 25 hours.

Discussion

The DT_ADD function returns a Date/Time variable containing one or more dates/times that have been offset a specified amount.

The keywords specify how the dates and/or times are incremented (added to). If no keyword is specified, the default increment is one day.

Only positive whole numbers (including zero) can be used with the keywords to specify an increment. Therefore, the smallest unit that can be added to *dt_var* is one second.

Example

This example shows how to add one day to a Date/Time variable containing two PV-WAVE Date/Time values.

```
dtarray = STR_TO_DT(['17-03-92', $
   '8-04-93'], Date_Fmt=2)
```

Convert two date strings to a Date/Time variable.

```
DT_PRINT, dtarray
   03/17/1992
   04/18/1993
```

The PV-WAVE Date/Time variable dtarray contains two dates.

```
dtarray1 = DT_ADD(dtarray, /Day)
```

Create a new PV-WAVE Date/Time variable dtarray1 that contains two dates with one day added to each date.

```
DT_PRINT, dtarray1
   03/18/1992
   04/19/1993
```

See Also

DT_SUBTRACT, DT_DURATION

DT_COMPRESS Function

Removes previously defined holidays and weekends from the Julian day portion of !DT structures in a Date/Time variable.

Usage

result = DT_COMPRESS(*dt_array*)

Input Parameters

dt_array — A Date/Time variable containing an array of Date/Time structures.

Returned Value

result — An array of double-precision values containing the compressed Julian days; that is, all days representing holidays and weekends are removed from each value of the array. In addition, the fractional time component of each Julian value is removed.

Keywords

None.

Discussion

This function is primarily used to generate compressed Date/Time data for specialized, user-written plotting applications, such as bar charts. If the *XType* keyword is set to 2, the compressed data can be used with the PLOT and OPLOT procedures.

Caution Avoid using DT_COMPRESS for normal XY plotting with the PLOT and OPLOT commands. Use the *Compress* keyword with PLOT and OPLOT to create compressed Date/Time results.

The value of the system variables !PDT.Exclude_Holiday and/or !PDT.Exclude_Weekend must be set to one (the default) before DT_COMPRESS is called. In addition, the functions CREATE_WEEKENDS and CREATE_HOLIDAYS must be run before you use DT_COMPRESS.

Note that the result of DT_COMPRESS is a double array of Julian days, not another array of !DT structures.

Example 1

This example demonstrates how DT_COMPRESS can be used to compress the weekend days from a Date/Time variable containing the days in the month of March, 1992. The resulting array of compressed Julian numbers is then processed so that it can be used to create a Date/Time plot in a specialized plotting application.

```
march1 = VAR_TO_DT(1992, 3, 1, 11, 30, 0)
PRINT, march1
   { 1992 3 1 11 30 0.00000 87462.479, 0}
```

Creates and prints out a variable march1 which is a PV-WAVE Date/Time variable. Note the Julian Day carefully, 87462. After compression, this value will be smaller. This is because all the weekends from Julian day 1 (September 14, 1752) are compressed.

```
marray = DTGEN(march1,31, /Day)
```

Generates a Date/Time array containing the 31 days of the month of March, 1992.

```
PRINT, marray
   { 1992 3 1 0 0 0.00000 87462.479 0}
   .
   .
   .
   { 1992 3 31 0 0 0.00000 87492.479 0}
```

```
CREATE_WEEKENDS, ['Saturday', 'Sunday']
```

Defines Saturday and Sunday as weekend days.

```
cmarray = DT_COMPRESS(marray)
PRINT, cmarray
   62472.5 62473.0 62474.0 62475.0
   62476.0 62477.0 62477.5 62477.5
   62478.0 62479.0 62480.0 62481.0
   62482.0 62482.5 62482.5 62483.0
   62484.0 62485.0 62486.0 62487.0
   62487.5 62487.5 62488.0 62489.0
   62490.0 62491.0 62492.0 62492.5
   62492.5 62493.0 62494.0
```

Creates and prints out a compressed array for the month of March, 1992. Weekend (compressed) days can be identified by fraction .5. Note that the values of the weekend days fall between the end and beginning of the week. Also note that the Julian numbers are smaller than in the original array. This is because all of the weekends from Julian day 1 are compressed.

The following block of code must be run before you can use this array of Julian numbers to generate a Date/Time axis. The DT_COMPRESS function removed the fractional Time portion of each Julian day, leaving date values with .0 or .5 appended to them. A .0 value indicates that the day is a weekday. A .5 value indicates a compressed day (a weekend). To generate a meaningful plot with this data, two things must be done.

First, the compressed days (the ones ending in .5) must be incremented to the value of the next whole day. Second, the Time portion of the Julian numbers representing weekdays must be restored.

The following code accomplishes both of these objectives:

```
FOR i=0, 30 DO BEGIN $
   whole_day = DOUBLE(FIX(cmarray(i))) $
   delta_day = cmarray(i) - whole_day $
   IF (delta_day GE 0.4) AND $
   (delta_day LE 0.6) THEN BEGIN $
```

Determine if a date value is a weekend day. If it is, then increment its value to the value of the next whole day.

```
   marray(i) = whole_day + 1.0d $
   ENDIF $
ELSE BEGIN $
   fract_day = marray(i).julian - $
   DOUBLE(FIX(marray(i).julian)) $
   cmarray(i) = whole_day + fract_day $
```

Restore the fractional portion of weekday Julian values from the original Date/Time array variable.

```
   ENDELSE $
ENDFOR
```

After this code is run, `cmarray` can be used to generate a Date/Time plot for a specialized plotting application—one where the regular PLOT routine is not sufficient. For example, this data could be used to generate a bar chart.

Before using this date data, however, you must first call PLOT or OPLOT with the *XType* keyword set to 2. This establishes the plot axis and coordinate system, and allows the Date/Time axis to be generated from an array of Julian numbers.

Example 2

This example defines some holidays for the year 1992 with the CREATE_HOLIDAYS procedure, creates an array with all the days of the year, and then excludes these holidays using the DT_COMPRESS function.

```
christmas = VAR_TO_DT(1992, 12, 25)
PRINT, christmas
   { 1992 12 31 0 0 0.00000 87761.000 0}
```

Create and print out a PV-WAVE Date/Time variable for Christmas. The purpose is to show the Julian day before using DT_COMPRESS. Note the Julian Day is 87761.

```
dayl = VAR_TO_DT(1992, 1, 1)
yarray = DTGEN(dayl, 366)
```

Create a variable day1 which is used to generate an array that contains all the days of the year (where 366 is used because 1992 is a leap year).

```
x = ['1-1-92', '5-31-92','7-4-92', $
   '-1-92', '11-24-92', '12-25-92']
```

Create an array containing date information for the following holidays: New Years, Memorial day, Fourth of July, Labor Day, Thanksgiving, and Christmas.

```
holidays = STR_TO_DT(x, Date_Fmt=1)
```

Create a PV-WAVE Date/Time variable for the holidays.

```
CREATE_HOLIDAYS, holidays
```

Define the holidays by setting the !Holiday_List system variable.

```
cyarray = DT_COMPRESS(yarray)
```

Creates an array that excludes the holidays for 1992. The compressed array cyarray appends the .5 decimal to all of the holidays. Non-holidays end in .0. When you print out cyarray, note the Julian day for Christmas is 87755.5. This is six days less than for the yarray, because six holidays were defined and compressed out of the result.

See Also

CREATE_HOLIDAYS, CREATE_WEEKENDS

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV-WAVE User's Guide.*

DT_DURATION Function

Standard Library function that determines the elapsed time between the values in two Date/Time variables.

Usage

result = DT_DURATION(*dt_var_1*, *dt_var_2*)

Input Parameters

dt_var_1 — The Date/Time variable to be subtracted from. Can be a scalar or array variable.

dt_var_2 — The Date/Time variable to subtract. Can be a scalar or array variable.

Returned Value

result — A double-precision array containing the difference between *dt_var_1* and *dt_var_2* in days and fractions of days.

Input Keywords

Compress — If present and nonzero, excludes predefined weekends and holidays from the calculation of duration. The default is no compression (0).

Discussion

If the input arrays are not of the same dimension, the output will be the size of the smallest input array.

Example

```
DT1 = str_to_dt('01-02-92', Date_Fmt=2)
DT2 = str_to_dt('01-03-92', Date_Fmt=2)
```

Create two Date/Time variables containing February 1, 1992 and March 1, 1992.

```
diff = DT_DURATION(DT2, DT1)
PRINT, diff
   29.000000
```

The difference between these dates is 29 days.

See Also

DT_ADD, DT_SUBTRACT

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV-WAVE User's Guide.*

DTGEN Function

Returns a PV-WAVE Date/Time array variable beginning with a specified date and incremented by a specified amount.

Usage

result = DTGEN(*dt_start*, *dimension*)

Input Parameters

dt_start – Date/Time variable containing a value representing the first date and time in the new data set.

dimension – Specifies the number of Date/Time values to generate.

Returned Value

result – A Date/Time array variable containing the specified number of Date/Time values.

Input Keywords

Year – Specifies an offset value in years.

Month – Specifies an offset value in months.

Day – Specifies an offset value in days.

Hour – Specifies an offset value in hours.

Minute – Specifies an offset value in minutes.

Second – Specifies an offset value in seconds.

Compress – If present and nonzero, excludes predefined weekends and holidays from the result. The default is no compression (0).

Note Only one keyword can be specified at a time. You cannot, for example, specify both years and months in a single DTGEN call.

But if you need to add, for example, one day and one hour, you can simply add 25 hours.

Discussion

Each value in the result is offset from the previous value by the amount specified with a keyword.

DTGEN lets you generate date and time data that match a particular dataset. For example, if you have gathered data at regular intervals, but do not have time stamps in your dataset, you can use DTGEN to generate date and time data that corresponds to your data-gathering intervals.

Only whole numbers (including zero) can be used with the keywords to specify the offset between dates and times. Therefore, the smallest unit by which generated dates can be offset is one second. If no keyword is specified, the default offset is one day.

Example 1

This example shows how to generate an array of PV‑WAVE Date/Time structures for consecutive years.

```
date1 = TODAY()
```

Create a PV‑WAVE Date/Time variable containing the current date.

```
date2 = DTGEN(date1, 4, /Year)
```

Use DTGEN to create a new PV‑WAVE Date/Time variable containing four Date/Time values. The four Date/Time values represent four consecutive years with identical months, days, and times.

```
PRINT, date2
   { 1992 3 26 6 28 50.0000 87487.270 0}
   { 1993 3 26 6 28 50.0000 87852.270 0}
   { 1994 3 26 6 28 50.0000 88217.270 0}
   { 1995 3 26 6 28 50.0000 88582.270 0}
```

Example 2

The second example shows how to create an array containing PV-WAVE Date/Time structures for every other month of a year.

```
date = VAR_TO_DT(1992, 1, 1)
```

Create a PV-WAVE Date/Time variable for January, 1992.

```
date1 = DTGEN(date, 6, Month=2)
```

Create an array variable containing PV-WAVE Date/Time data for every other month of the year 1992.

```
PRINT, date1
   { 1992 1 1 0 0 0.00000 87402.000 0}
   { 1992 3 1 0 0 0.00000 87462.000 0}
   { 1992 5 1 0 0 0.00000 87523.000 0}
   { 1992 7 1 0 0 0.00000 87584.000 0}
   { 1992 9 1 0 0 0.00000 87646.000 0}
   { 1992 11 1 0 0 0.00000 87707.000 0}
```

See Also

DT_ADD

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV-WAVE User's Guide*.

DT_PRINT Procedure

Standard Library procedure that prints the values in PV-WAVE Date/Time variables in a readable format.

Usage

DT_PRINT, *dt_var*

Input Parameters

dt_var — A PV-WAVE Date/Time variable containing one or more Date/Time structures.

Keywords

None.

Discussion

The system variables !Date_Separator and !Time_Separator determine which characters are used to separate the date and time elements in the output. The default delimiter for dates is a slash (/), and the default delimiter for printing times is a colon (:). For example:

```
4/2/1992 7:7:51
```

You can change these separators by changing the values of !Date_Separator and !Time_Separator.

Examples

```
x = TODAY()
DT_PRINT, x
   05/06/1992 14:34:54
PRINT, x
   { 1992 5 6 14 34 54.0000 87528.608 0}
```

```
dtarray = DTGEN(x,4)
DT_PRINT, dtarray
   4/2/1992 7:7:51.000
   4/3/1992 7:7:51.000
   4/4/1992 7:7:51.000
   4/5/1992 7:7:51.000
```

See Also

!Date_Separator, !Time_Separator

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV‑WAVE User's Guide*.

DT_SUBTRACT Function

Decrements the values in a Date/Time variable by a specified amount.

Usage

result = DT_SUBTRACT(*dt_var*)

Input Parameters

dt_var – The original PV‑WAVE Date/Time variable or array of variables.

Returned Value

result – A PV‑WAVE Date/Time variable decremented by the specified amount.

Input Keywords

Compress – If present and nonzero, excludes predefined weekends and holidays from the result. The default is no compression (0).

Output Keywords

Year – Specifies an offset value in years.

Month – Specifies an offset value in months.

Day – Specifies an offset value in days.

Hour – Specifies an offset value in hours.

Minute – Specifies an offset value in minutes.

Second – Specifies an offset value in seconds.

Note Only one keyword can be specified at a time. You cannot, for example, specify both years and months in a single DT_SUBTRACT call. But if you need to subtract, for example, one day and one hour, you can simply subtract 25 hours.

Discussion

The DT_SUBTRACT function returns a Date/Time variable containing one or more dates/times that have been offset by the specified amount.

The keywords specify how the dates and/or times are decremented (subtracted from). If no keyword is specified, the default decrement is one day.

Only positive whole numbers (including zero) can be used with the keywords to specify a decrement. Therefore, the smallest unit that can be subtracted from *dt_var* is one second.

Example 1

```
dtvar = VAR_TO_DT(1992, 03, 17, 09, 30, 54)
```

Create a PV-WAVE Date/Time variable containing a Date/Time.

```
dtvar1= DT_SUBTRACT(dtvar, Year=4)
```

Create a new PV-WAVE Date/Time variable by subtracting 4 years from dtvar.

```
PRINT, dtvar1
   { 1988 3 17 9 30 54.0000 86017.396 0}
```

Display the new PV-WAVE Date/Time variable.

Example 2

This example shows how to add one day to a Date/Time variable containing two PV-WAVE Date/Time values.

```
dtarray = STR_TO_DT(['17-03-92', $
   '8-04-93'], Date_Fmt=2)
```

Convert two date strings to a Date/Time variable.

```
DT_PRINT, dtarray
   03/17/1992
   04/18/1993
```

The PV-WAVE Date/Time variable dtarray contains two dates.

```
dtarray1 = DT_SUBTRACT(dtarray, /Day)
```

Create a new PV-WAVE Date/Time variable dtarray1 that contains two dates with one day subtracted from each date.

```
DT_PRINT, dtarray1
   03/16/1992
   04/17/1993
```

Example 3

This example shows the effect of using the *Compress* keyword with DT_SUBTRACT. Assume that you have defined Christmas (December 25, 1992) to be a holiday with the procedure CREATE_HOLIDAYS.

```
x = VAR_TO_DT(1992, 12, 26)
```

Begin with a date variable containing December 26, 1992.

```
y = DT_SUBTRACT(x, /Day, /Compress)
```

Subtract one day from the variable.

```
DT_PRINT, y
   12/24/1992
```

The result is December 24. Normally, the result would be 12/25/92, but because December 25 is defined as a holiday, the Compress keyword causes the 25th to be skipped.

See Also

DT_ADD, DT_DURATION

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV‑WAVE User's Guide*.

DT_TO_SEC Function

Standard Library function that converts a PV‑WAVE Date/Time variable to a double-precision variable containing the number of seconds elapsed from a base date.

Usage

result = DT_TO_SEC(*dt_var*)

Input Parameters

dt_var – A PV‑WAVE Date/Time variable.

Returned Value

result – A double-precision variable containing the number of seconds elapsed between the base date and the date(s) contained in *dt_var*. The value of the base date is maintained in the system variable !DT_Base.

Keywords

Base – A string containing a date, such as "3-27-92". This is the base date from which the number of elapsed seconds is calculated. *Base* can be used to override the default value in the system variable !DT_Base.

Date_Fmt – Specifies the format of the base date, if passed into the function. Possible values are 1, 2, 3, 4, or 5, as summarized in the following table:

Table 2-6: Valid Date Formats

Value	Format Description	Examples for May 1, 1992
1	MM*DD*[YY]YY	05/01/92
2	DD*MM*[YY]YY	01-05-92
3	ddd*[YY]YY]	122,1992
4	DD*mmm[mmmmmm]*[YY]YY	01/May/92
5	[YY]YY*MM*DD	1992-05-01

where the asterisk (*) represents one of the following separators: dash (–), slash (/), comma (,), period (.), or colon (:).

For a detailed description of these formats, see Chapter 7, *Working with Date/Time Data*, in the *PV-WAVE User's Guide.*

Discussion

This function is useful for converting Date/Time values to relative time. The default base date is September 14, 1752.

Example1

Assume that you have created the array `dtarray` that contains the following PV-WAVE Date/Time data:

```
date1=[{!dt,
   1992,3,27,7,18,57.0000,87488.305,0},$
{!dt, 1993,3,27,7,18,57.0000,87853.305,0}, $
{!dt, 1994,3,27,7,18,57.0000,87218.305,0}]
```

To find out the number of seconds for each date from the default base, September 14, 1752, use:

```
seconds = DT_TO_SEC(dtarray)
PRINT, seconds
   7.5589031e+09 7.5904391e+09 7.5355751e+09
```

Example 2

Assume that you have created the array `dtarray` that contains the following PV-WAVE Date/Time data:

```
date1=[{!dt,
   1992,4,15,7,29,19.0000,87507.312,0}$
{!dt, 1993,4,15,7,29,19.0000,87872.312,0} $
{!dt, 1994,4,15,7,29,19.0000,88237.312,0}]
```

To find out the number of seconds for each date from January 1, 1970, use:

```
seconds = DT_TO_SEC(dtarray, $
   Base='1-1-70', Date_Fmt=1)
PRINT, seconds
   7.0332296e+08 7.3485896e+08 7.6639496e+08
```

See Also

SEC_TO_DT, DT_TO_VAR, DT_TO_STR, !DT_Base

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV-WAVE User's Guide*.

DT_TO_STR Procedure

Converts PV-WAVE Date/Time variables to string data.

Usage

DT_TO_STR, *dt_var*, [, *dates*] [, *times*]

Input Parameters

dt_var – A Date/Time variable containing one or more Date/Time structures.

Output Parameters

dates – A variable containing the date strings extracted from the PV-WAVE Date/Time variable.

times – A variable containing the time strings extracted from PV-WAVE Date/Time variable.

Keywords

Date_Fmt – Specifies the format of the date data in the input variable. Possible values are 1, 2, 3, 4, or 5, as summarized in the following table:

Table 2-7: Valid Date Formats

Value	Format Description	Examples for May 1, 1992
1	MM*DD*YYYY	05/01/1992
2	DD*MM*YYYY	01-05-1992
3	ddd*YYYY	122,1992
4	DD*mmm[mmmmmm]*YYYY	01/May/1992
5	YYYY*MM*DD	1992-05-01

where the asterisk (*) represents one of the following separators: dash (–), slash (/), comma (,), period (.), or colon (:).

Time_Fmt – Specifies the format of the time portion of the data in the input variable. Possible values are –1 or –2, as summarized in the following table:

Table 2-8: Valid Time Formats

Value	Format Description	Examples for 1:30 p.m.
–1	HH*Mn*SS.sss	13:30:35.25
–2	HHMn	1330

where the asterisk (*) represents one of the following separators: dash (–), slash (/), comma (,), or colon (:). No separators are allowed between hours and minutes for the –2 format. Both hours and minutes must occupy two spaces.

Note Date and time separators are specified with the !Date_Separator and !Time_Separator system variables. It is possible to use any character or string as a separator with the DT_TO_STR function; however, if you use a non-standard separator (one other than dash (–), slash (/), comma (,), period (.), or colon (:)), you will be unable to convert the data back to a Date/Time variable with STR_TO_DT. If Either of these system variables is set to an empty string, then you receive a default separator.

You must specify a date and/or time format if the *dates* and/or *times* parameters are specified.

Examples

Assume you have a PV-WAVE Date/Time variable named `date1` that contains the following Date/Time structures:

```
date1=[{!dt,
   1992,3,13,1,10,34.0000,87474.049,0}$
{!dt, 1983,4,20,16,18,30.0000,84224.680,0} $
{!dt, 1964,4,24,5,7,25.0000,77289.213,0}]
```

To convert to string data, use the DT_TO_STR procedure:

```
DT_TO_STR, date1, d, t, Date_Fmt=1, $
   Time_Fmt=-1
```

Convert PV-WAVE Date/Time data. Store the date data in d and the time data in t.

```
PRINT, d
   3/13/1992 4/20/1983 4/24/1964
PRINT, t
   01:10:34 16:18:30 05:07:25
```

See Also

STR_TO_DT, DT_TO_VAR, DT_TO_SEC, !Time_Separator, !Date_Separator

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV-WAVE User's Guide*.

DT_TO_VAR Procedure

Standard Library procedure that converts a PV-WAVE Date/Time variable to regular numerical data.

Usage

DT_TO_VAR, *dt_var*

Input Parameters

dt_var – A PV-WAVE Date/Time variable.

Output Keywords

Year – Specifies an integer variable to contain the years.

Month – Specifies a byte variable to contain the months.

Day – Specifies a byte variable to contain the days of the month.

Hour – Specifies a byte variable to contain the hours.

Minute – Specifies a byte variable contain the minutes.

Second – Specifies a floating-point variable to contain the seconds and fractional seconds.

Discussion

Use one or more keywords to specify the kind of output produced by this procedure. For example, to create a new variable containing the years in the Date/Time variable `mydtvar`, use:

```
   DT_TO_VAR, mydtvar, year=myyear
```

The result is a new variable called `myyear` that contains integer values.

Example

Assume that you have created a PV-WAVE Date/Time variable named date1 that contains the following Date/Time data:

```
date1=[{!dt,
   1992,3,13,10,34,15.000,87474.440,0}$
{!dt, 1983,4,20,12,30,19.000,84224.521,0}$
{!dt, 1964,4,24,16,25,14.000,77350.684,0}]
```

To extract each Date/Time element into a separate variable:

```
DT_TO_VAR, date1, Year=years, $
   Month=months, Day=days
```

This procedure creates several variables containing the Date/Time data.

```
PRINT, "Years = ", years
   Years = 1992 1983 1964

PRINT, "Months = ", months
   Months = 3 4 6

PRINT, "Days = ", days
   Days = 13 20 24
```

See Also

VAR_TO_DT, DT_TO_STR, DT_TO_SEC

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV-WAVE User's Guide.*

EMPTY Procedure

Causes all buffered output for the current graphics device to be written.

Usage

EMPTY

Parameters

None.

Keywords

None.

Discussion

PV-WAVE uses buffered output on many image devices for reasons of efficiency. This leads to rare occasions where a program needs to be certain that data are not waiting in a buffer, but have actually been output. This procedure is handy for such occasions.

EMPTY is a low-level graphics routine. PV-WAVE graphics routines generally handle the flushing of buffered data transparently to you, so the need for EMPTY is extremely rare.

See Also

FLUSH

ENVIRONMENT Function

(UNIX Only) Returns a string array containing all the UNIX environment strings for the PV‑WAVE process.

Usage

result = ENVIRONMENT( )

Parameters

None.

Returned Value

A string array containing all the UNIX environment strings for the PV‑WAVE process. Each element of the result contains one environment string.

Keywords

None.

Discussion

Like any UNIX process, PV‑WAVE inherits its environment from its parent process, which is usually the shell.

Example

```
p = ENVIRONMENT()
PRINT, p
```

See Also

GETENV, SETENV

EOF Function

Tests the specified file unit for the end-of-file condition.

Usage

result = EOF(*unit*)

Input Parameters

unit – The logical unit number (LUN) of the file to be tested.

Returned Value

result – Returns 1 if the file is positioned at the end of the file. Otherwise, returns 0.

Keywords

None.

Discussion

Under VMS, the EOF function has the following limitations:

- It does not work with files accessed via DECNET.
- It is meaningless when used with files having an indexed organization structure.

In such cases, we recommend using the ON_IOERROR procedure to handle end-of-file.

Example

In this example, a file of test data is created. That file is then read and printed until the end-of-file condition is detected by EOF.

```
OPENW, unit, 'eoffile.dat', /Get_Lun
```
Open the file eoffile.dat for writing.

```
PRINTF, unit, 'This is'
PRINTF, unit, 'some sample'
PRINTF, unit, 'data.'
```
Write some text to the file.

```
FREE_LUN, unit
```
Close the file and free the associated unit number.

```
OPENR, unit, 'eoffile.dat', /Get_Lun
```
Open the file eoffile.dat for reading.

```
a = ' '
```
Define a string variable.

```
WHILE NOT eof(unit) DO BEGIN &$
    READF, unit, a &$
    PRINT, a &$
```
Read data and print it until end-of-file.

```
ENDWHILE
```

```
This is
some sample
data.
```

```
FREE_LUN, unit
```

See Also

ON_IOERROR, RETALL, RETURN

For information on opening files and choosing LUNs, see *Opening and Closing Files* on page 138 of the *PV-WAVE Programmer's Guide.*

ERASE Procedure

Erases the display surface of the currently active window.

Usage

ERASE [, *background_color*]

Input Parameters

background_color – The background color index.

Caution Not all devices support this parameter. Workstations and display terminals, such as X workstations and Tektronix terminals, generally do, while some hardcopy devices, such as HPGL plotters, do not.

Input Keywords

Channel – The destination channel index or mask for the operation. Use only with devices with multiple display channels. If *Channel* is omitted, the system variable !P.Channel is used.

Color – The background color index. If specified (and the parameter *background_color* is not specified), *Color* overrides the value of the system variable !P.Background.

Discussion

ERASE is a low-level graphics routine. It resets the display surface to the default background color (normally 0), which is indexed from the current color translation tables by the system variable !P.Background. You can override the default by specifying *background_color.*

ERASE affects the current window only; to switch windows, use the WINDOW command.

A side effect of ERASE is that the device is reset to alphanumeric mode if it has such a mode (e.g., Tektronix terminals).

Example 1

```
WAVE> ERASE
```

Erase the display surface for the current window and use the value in !P.Background to set the background color.

Example 2

```
WAVE> COLOR_PALETTE
```

Create a color palette so the color table can be easily viewed.

```
WAVE> LOADCT, 2
```

Load in color table 2, GRN-RED-BLU-WHT, as it has distinctive colors.

```
WAVE> WINDOW, 1
```

Create window 1.

```
WAVE> ERASE
```

Erase it using !P.Background.

```
WAVE> WINDOW, 2
```

Create window 2.

```
WAVE> ERASE, 22
```

Erase it, setting the background color to 22 (lime green).

```
WAVE> WINDOW, 1
```

Switch back to window 1.

```
WAVE> ERASE, 64
```

Reset the background color to 64 (bright red).

```
WAVE> WINDOW, 2
```

Switch back to window 2.

```
WAVE> !P.Background=180
```

Explicitly set the background color to 180 (lavender).

```
WAVE> ERASE
```

Set the background color based on !P.Background.

See Also

!P.Background, WDELETE, WINDOW

ERODE Function

Implements the morphologic erosion operator for shape processing.

Usage

result = ERODE(*image, structure* [, x_0, y_0])

Input Parameters

image – The array to be eroded.

structure – The structuring element. May be a one- or two-dimensional array. Elements are interpreted as binary (values are either zero or nonzero), unless the *Gray* keyword is used.

x_0 – The X coordinates of *structure*'s origin.

y_0 – The Y coordinates of *structure*'s origin.

Returned Value

result – The eroded image.

Input Keywords

Gray – A flag which, if present, indicates that gray scale, rather than binary erosion, is to be used.

Values – An array providing the values of the structuring element. Must have the same dimensions and number of elements as *structure.*

Discussion

If *image* is not of the byte type, PV-WAVE makes a temporary byte copy of *image* before using it for the processing.

The optional parameters x_0 and y_0 specify the row and column coordinates of the structuring element's origin. If omitted, the origin is set to the center, ($\lfloor N_x / 2 \rfloor$, $\lfloor N_y / 2 \rfloor$), where N_x and N_y are the dimensions of the structuring element array. However, the origin need not be within the structuring element.

Nonzero elements of the *structure* parameter determine the shape of the structuring element (neighborhood).

Note If the *Values* keyword is not used, all elements of the structuring element are 0, yielding the neighborhood minimum operator.

You can choose whether you want to use gray scale or binary erosion:

- If you select binary erosion type, the image is considered to be a binary image with all nonzero pixels considered as 1. (You will automatically select binary erosion if you don't use either the *Gray* or *Values* keyword.)
- If you select gray scale erosion type, each pixel of the result is the minimum of the difference of the corresponding elements of *Values* overlaid with *image*. (You will automatically select gray scale erosion if you use either the *Gray* or *Values* keyword.)

Background Information

The ERODE function implements the morphologic erosion operator on binary and gray scale images and vectors. Mathematical morphology provides an approach to the processing of digital images on the basis of shape. This approach is summarized in the description of the DILATE function. Erosion is the complement (dual) of dilation; it does to the background what dilation does to the foreground.

Briefly, ERODE returns the erosion of *image* by the structuring element, *structure*. This operation is also commonly known as contracting or reducing. It can be used to remove islands smaller than the structuring element.

The result is an image that contains items that now contract away from each other. Features that either slightly touch or are connected by narrow areas may disconnect, becoming separate, smaller objects. Any holes or gaps in or between features become larger as the features in the image shrink away from each other. Sharp-edged items and harsh angles typically become dull as they are worn away; however, in some cases areas that were dull may become somewhat sharper as a feature erodes away.

Note Erosion can be used to change the morphological structure of objects or features in an image to see what would happen if they were to actually shrink over time.

Used with gray scale images, which are always converted to a byte type, the ERODE function is accomplished by taking the minimum of a set of differences. It may be conveniently used to implement the neighborhood minimum operator, with the shape of the neighborhood given by the structuring element.

Used with binary images, the origin of the structuring element is moved to each pixel of the image. If each nonzero element of the structuring element is contained in the image, the output pixel is set to one.

Letting A θ B represent the erosion of an image *A* by structuring element *B*, erosion may be defined as:

$$C = A \theta B = \bigcap_{b \in B} (A)_{-b}$$

where $(A)_{-b}$ represents the translation of *A* by *b*. The structuring element *B* may be visualized as a probe which slides across the image *A*, testing the spatial nature of *A* at each point. Where *B* translated by *i, j* can be contained in *A* (by placing the origin of *B* at *i, j*), then $A_{i,j}$ belongs to the erosion of *A* by *B*.

Example 1

In this example, the origin of the structuring element is at (0, 0):

```
0100            0000
0100            0000
1110 θ 11 =     1100
1000            0000
0000            0000
```

Example 2

Here is what an aerial image looks like before and after applying the ERODE function three different times. For this example, the following parameters were used each time:

```
   img = ERODE(aerial_img, struct, /Gray)
```

where `struct` has a value of [1 0 1].

Because the ERODE function was applied to the image three times, the “blurring” is more pronounced that it would have been with only one erosion.

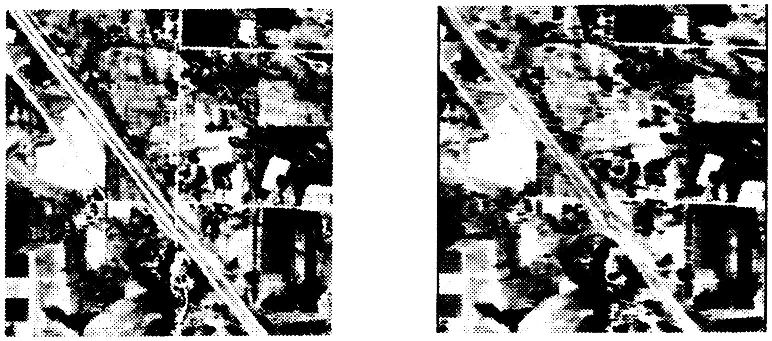


Figure 2-12 The ERODE function has been used to “wear away” the visual elements of this 512-by-512 aerial image.

See Also

DILATE

ERRORF Function

Calculates the standard error function of the input variable.

Usage

result = ERRORF(*x*)

Input Parameters

x — The expression for which the error function will be evaluated.

Returned Value

result — The standard error function of *x*. It is of floating-point data type, and has the same dimensions as *x*.

Keywords

None.

Discussion

The standard error function is central to many calculations in statistics. The ERRORF function can be used in a variety of applications; one example is to solve diffusion equations in heat transfer problems.

The error function is a special case of the incomplete gamma function. ERRORF is defined as:

$$\left(\frac{2}{\sqrt{\pi}}\right) \int_0 e^{-t^2} dt$$

ERRORF has the following limiting values and symmetries:

$erf(0) = 0$

$erf(\infty) = 1$

$$erf(-x) = -erf(x)$$

It is related to the incomplete gamma function by:

$$erf(x) = \Gamma(1/2, x^2)$$

where $x \geq 0$.

See Also

GAMMA

The method used to determine the error function of complex operands is taken from: W. Gautschi, "Efficient computation of the complex error function," *Siam Journal of Numerical Analysis*, Volume 7, page 187, 1970.

ERRPLOT Procedure

Standard Library procedure that overplots error bars over a previously-drawn plot.

Usage

ERRPLOT [, *points*], *low, high*

Input Parameters

points – A vector containing the independent or abscissae values of the function. If *points* is omitted, the abscissae values are taken to be unit distances along the X axis, beginning with 0.

low – A vector containing the lower bounds of the error bars. The value of *low(i)* is equal to the data value at *i* minus the lower error bound.

high – A vector containing the upper bounds of the error bars. The value of *high(i)* is equal to the data value at *i* plus the upper error bound.

Input Keywords

Width – The width of the error bars. If omitted, the width is set to one percent of the plot width.

Discussion

Error bars are drawn for each element. They extend from *low* to *high*.

Example

Assume the vector y contains the data values to be plotted, and that `err` is the symmetrical error estimate. The PV-WAVE commands to plot the data and overplot the error bars are:

```
y = [4.0, 5.0, 3.0, 3.0, 2.0]
err = 0.2
PLOT, y, Yrange=[1, 6]
ERRPLOT, y—err, y+err
```

If the error estimates are asymmetrical, they should be placed in the vectors *low* and *high*. For example:

```
low = [3.5, 4.8, 2.5, 2.7, 1.9]
high = [4.3, 5.1, 3.5, 3.2, 2.1]
PLOT, y, YRange=[1, 6]
ERRPLOT, low, high
```

This produces the plot below:

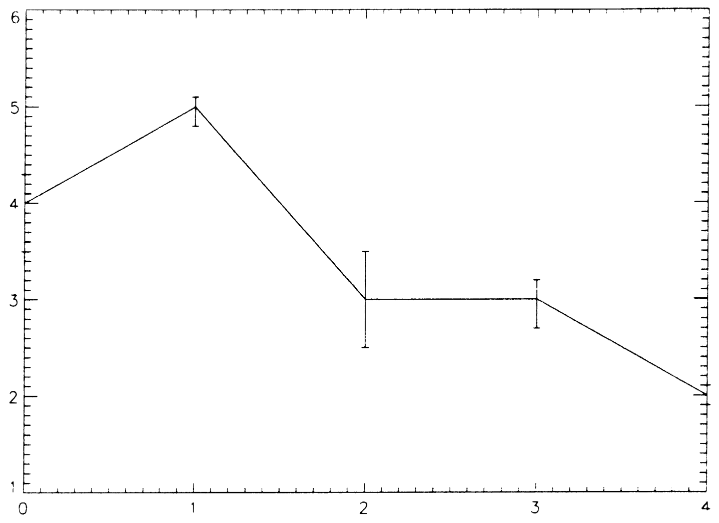


Figure 2-13 In this example, asymmetrical error estimates have been constrained by using ERRPLOT's *low* and *high* parameters.

To plot error bars versus a vector containing specific points along the X axis, use the following commands:

```
points = [1.0, 3.0, 4.0, 6.0, 7.0]
PLOT, points, y, YRange=[1, 6]
ERRPLOT, points, low, high
```

This produces the plot shown below:

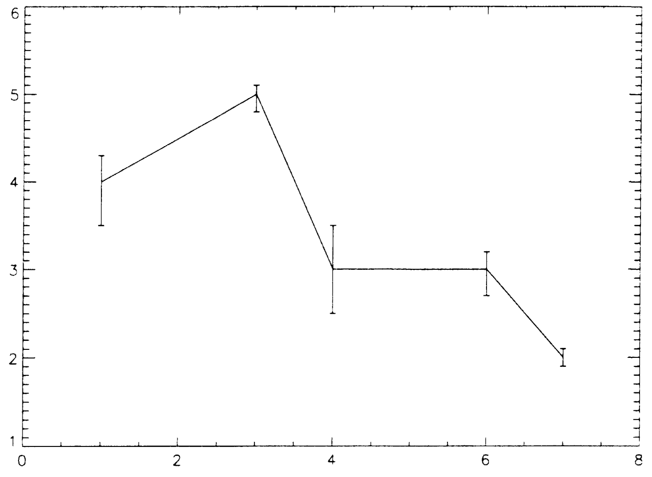


Figure 2-14 In this example, error bars have been plotted over a vector containing specific points along the X axis.

See Also

OPLOT, OPLOTERR, PLOT, PLOTERR

EXEC_ON_SELECT Procedure

Registers callback procedures on input for a vector of logical unit numbers (LUNs).

Usage

EXEC_ON_SELECT, *luns*, *commands*

Input Parameters

luns – Vector of logical unit numbers.

commands – Vector of procedure names. It must have the same number of entries as the vector *luns*.

Input Keywords

Widget – If present and nonzero, resisters LUNs and commands with the WAVE Widgets or Widget Toolbox event loop (WwLoop or WtLoop).

Just_reg – If present and nonzero, registers the unit numbers and callback procedures. Do not wait for any input. This is useful when this procedure is used with widgets.

Description

This procedure checks for input on all the logical unit numbers specified in the *luns* vector. When there is input available on *luns* (*k*) , the *commands* (*k*) procedure is called with *luns* (*k*) as its (only) argument. This procedure never returns; it just keeps handling callbacks when input is available.

Example 1

In this example, three servers are started and their output handled using EXEC_ON_SELECT. For simplicity, the servers are all the same program, `EX1`, with a different command line argument. The servers occasionally output a four-byte integer. This input is handled by the callback procedures SERVER1, SERVER2, SERVER3. The server is the following C program:

```
#include <stdio.h>
#include <string.h>

main(int argc, char *argv[])
   {
      int tag = atoi(argv[1]);
          for (; ;) {
          sleep(5);
          write(1, &tag, sizeof(tag));
      }
   }
```

The following are the PV-WAVE procedures that use the above server:

```
PRO SERVER1, lun
   code = 0L
   READU, lun, code
   PRINT, 'SERVER1', code
END

PRO SERVER2, lun
   code = 0L
   READU, lun, code
   PRINT, 'SERVER2', code
END

PRO SERVER3, lun
   code = 0L
   READU, lun, code
   PRINT, 'SERVER3', code
END

PRO EX1
```

Start servers.

```
   SPAWN, 'EX1 1', Unit = lun1, /Sh
   SPAWN, 'EX1 2', Unit = lun2, /Sh
```

```
    SPAWN, 'EX1 3', Unit = lun3, /Sh
```

Handle servers.

```
    EXEC_ON_SELECT, [lun1, lun2, lun3], $
       ['SERVER1', 'SERVER2', 'SERVER3']
END
```

Example 2

This example is an extension of the previous example. Again, three servers are started and their output handled using EXEC_ON_SELECT. The input is handled by the callback procedures SERVER1, SERVER2, SERVER3. Now, a widget menu also is displayed and serviced. The EXEC_ON_SELECT procedure registers the LUNs and callback procedures with the WAVE Widgets event loop (WwLoop) and returns values using the *Widget* and *Just_reg* keywords.

When there is input, WwLoop calls the appropriate callback routine to handle the input and returns to waiting for more input.

```
PRO SERVER1, top, data, nparams, id, lun
    code = 0L
    READU, lun, code
    PRINT, 'SERVER1', code, lun

END

PRO SERVER2, top, data, nparams, id, lun
    code = 0L
    READU, lun, code
    PRINT, 'SERVER2', code, lun

END

PRO SERVER3, top, data, nparams, id, lun
    code = 0L
    READU, lun, code
    PRINT, 'SERVER3', code, lun

END
```

```
PRO MenuCB, wid, index
```

Create a menu.

```
    PRINT, 'Menu Item', index, ' selected.'
    value = WwGetValue(wid)
    PRINT, value
END

PRO Ex2
    SPAWN, 'EX1 1', unit = lun1, /sh
    SPAWN, 'EX1 2', unit = lun2, /sh
    SPAWN, 'EX1 3', unit = lun3, /sh

 top = WwInit('ex2','Test',layout,/Vertical)

 button = WwButtonBox(layout, ['Fonts',$
   'Size','Icons'],'MenuCB')

 status = WwSetValue(top, /Display)

 EXEC_ON_SELECT, [lun1, lun2, lun3], $
   ['SERVER1','SERVER2','SERVER3'], /Widget,$
      /Just_reg

 WwLoop

 CLOSE, lun1, lun2, lun3

END
```

See Also

SELECT_READ_LUN, ADD_EXEC_ON_SELECT, DROP_EXEC_ON_SELECT

EXECUTE Function

Compiles and executes one or more PV-WAVE statements contained in a string at run-time.

Usage

result = EXECUTE(*string*)

Input Parameters

string – A string containing the PV-WAVE command(s) to be compiled and executed. Cannot contain a command that starts with either a dollar ($) or period (.) character; such commands must be entered at the PV-WAVE prompt.

Returned Value

result – Returns 1 if the string was successfully compiled and executed; returns 0 if an error occurs during either phase.

Keywords

None.

Example

This example creates a procedure, TABLE, that prints a table giving the results of evaluating a user-defined function of two variables at the values in two vectors. A user-defined printing procedure is used to actually display the table of values.

Function EXECUTE is used to invoke both the user-defined function of two variables and the user-defined printing procedure. The name of the function is passed to TABLE using keyword *Func*, and the name of the printing procedure is passed using keyword *Prt_Pro*. The following is a listing of TABLE:

```
PRO TABLE, x, y, Func = func, Prt_Pro = pp

tab = FLTARR(3, n_elements(x))
tab(0, *) = x
tab(1, *) = y

val = EXECUTE('tab(2, *) = ' $
   + func + '(tab(0, *), tab(1, *))')
```

Use EXECUTE to invoke the function in the string variable func. Assign the result to column 2 of tab.

```
IF val EQ 1 THEN BEGIN

   val = EXECUTE(pp + ', tab')
```

Use EXECUTE to invoke the procedure in the string variable pp. This procedure prints the table.

```
   IF val EQ 0 THEN BEGIN
      PRINT, "***Error in execution of " + $
      "printing procedure! ***"

   ENDIF

ENDIF ELSE BEGIN

   PRINT, "*** Error in execution of " + $
      "function! ***"

ENDELSE

END
```

If this procedure is placed in the file `table.pro` in your working directory, it will be compiled automatically when it is invoked. Note that the string concatenation operator, along with several string literals, are used to construct the statements to execute using EXECUTE.

The user-defined function requires two arguments, which are the values of the independent variables of the function. The function should return the result of the function evaluation. The user-defined printing procedure requires one argument, which is the two-dimensional table to be printed. The following commands can be entered at the PV-WAVE interactive prompt to create and compile a function of two variables:

```
.RUN
- FUNCTION fcn, x, y
- RETURN, x^2 - y^2
- END
```

The following procedure prints the table:

```
PRO prt, arr
PRINT, Format = $
   '(4x, "x", 13x, "y", 10x, "func(x, y)")'
PRINT, Format = '(39("-"))'
PRINT, Format = '(2(f9.4, 5x), f10.4)', arr
END
```

If this procedure is placed in the file `prt.pro` in your working directory, it will be compiled automatically when it is invoked. The following commands can be used to create the vectors of values at which to evaluate *fcn* and to invoke TABLE:

```
x = [1, 2, 3, 4, 5]
y = REVERSE(x)

TABLE, x, y, Func = 'fcn', Prt_pro = 'prt'
 x             y          func(x, y)
---------------------------------------
 1.0000        5.0000       -24.0000
 2.0000        4.0000       -12.0000
 3.0000        3.0000         0.0000
 4.0000        2.0000        12.0000
 5.0000        1.0000        24.0000
```

See Also

For more information, see *Executing One or More Statements* on page 273 of the *PV-WAVE Programmer's Guide.*

EXIT Procedure

Exits PV-WAVE and returns you to the operating system.

Usage

EXIT

Parameters

None.

Keywords

None.

Discussion

All buffers are flushed and open files are closed. The values of all variables that were not saved are lost.

See Also

QUIT

EXP Function

Raises e to the power of the value of the input variable.

Usage

result = EXP(*x*)

Input Parameters

x — The value to be evaluated.

Returned Value

result — The natural exponential function of *x*.

Keywords

None.

Discussion

EXP is defined as:

$$y = e^x$$

If *x* is of double-precision floating-point or complex data type, EXP yields results of the same type. All other types yield a single-precision floating-point result.

EXP handles complex values in the following way:

$$exp(x) = complex(e^r cos(i), e^r sin(i))$$

where *r* is the real part of *x*, and *i* is the imaginary part of *x*. If *x* is an array, the result has the same dimensions as *x*, with each element containing the result for the corresponding element of *x*.

Example

```
exp_of_1 = EXP(1)
PRINT, exp_of_1
   2.71828
exp_of_0 = EXP(0)
PRINT, exp_of_0
   1.00000
exp_of_10 = EXP(10)
PRINT, exp_of_10
   22026.5
```

See Also

For a list of other transcendental functions, see *Transcendental Mathematical Functions* on page 20.

FAST_GRID2 Function

Returns a gridded, 1D array containing Y values, given random X,Y coordinates (this function works best with dense data points).

Usage

result = FAST_GRID2(*points, grid_x*)

Input Parameters

points — A (2, *n*) array containing the random X,Y points to be gridded.

grid_x — The X dimension of the grid. The X values are scaled to fit this dimension.

Returned Value

result — A gridded 1D array containing Y values.

Input Keywords

Iter — The number of iterations on the smooth function. The execution time increases linearly with the number of iterations. The default is 3, but any non-negative integer (including zero) may be specified.

Nghbr — The size of the neighborhood to smooth. If not supplied, the neighborhood size is calculated from the distribution of the points. The amount of memory required increases by the square of the neighborhood size.

No_Avg — Normally, if multiple data points fall in the same cell in the gridded array, then the value of that cell is the average value of all the data points that fall in that cell.

If the *No_Avg* keyword is present and nonzero, however, the value of the cell in the gridded array is the total of all the points that fall in that cell.

XMin – The X coordinate of the left edge of the grid. If omitted, maps the minimum X value found in the *points(0, *)* array to the left edge of the grid.

XMax – The X coordinate of the right edge of the grid. If omitted, maps the maximum X value found in the *points(0, *)* array to the right edge of the grid.

Discussion

FAST_GRID2 uses a neighborhood smoothing technique to interpolate missing data values for 2D gridding. The gridded array returned by FAST_GRID2 is suitable for use with the PLOT function.

FAST_GRID2 is similar to GRID_2D. FAST_GRID2, however, works best with dense data points (more than 1000 points to be gridded) and is considerably faster, but slightly less accurate, than GRID_2D. (GRID_2D works best with sparse data points and is stable when extrapolating into large void areas.)

Tip For best results, use a small neighborhood (such as 3) and a large number of iterations (more than 16).

Examples

```
PRO f_gridemo2
```

This program shows 2D gridding with dense data points.

```
points = INTARR(2, 10)
points(*, 0) = [1,2]
points(*, 1) = [2,3]
points(*, 2) = [5,5]
points(*, 3) = [8,0]
points(*, 4) = [9,6]
points(*, 5) = [4,9]
points(*, 6) = [7,15]
points(*, 7) = [6,-5]
points(*, 8) = [0,3]
points(*, 9) = [0,-1]
```

Set up the data points.

```
WINDOW, 0, Colors=128
LOADCT, 4
T3D, /Reset
```

Set up the viewing window and load the color table.

```
!Y.Range = [MIN(points), MAX(points)]
```

Set the Y axis range for plotting.

```
yval = FAST_GRID2(points, 256, Iter=0)
PLOT, yval, Color=60
yval = FAST_GRID2(points, 256, Iter=150,$
   Nghbr=3)
OPLOT, yval, Color=80
yval = FAST_GRID2(points, 256, Nghbr=77)
OPLOT, yval, Color=100
yval = FAST_GRID2(points, 256)
OPLOT, yval, Color=120
```

Grid and plot the points using different values for the neighborhood and number of iterations.

```
!Y.Range = [0.0, 0.0]
```

Reset the Y axis range to the default value.

```
END
```

See Also

GRID_2D, GRID_3D, GRID_4D, GRID_SPHERE, FAST_GRID3, FAST_GRID4

For information on the optional software package for advanced gridding, PV-WAVE:GTGRID, contact your Visual Numerics account representative.

FAST_GRID3 Function

Returns a gridded, 2D array containing Z values, given random X, Y, Z coordinates (this function works best with dense data points).

Usage

result = FAST_GRID3(*points, grid_x, grid_y*)

Input Parameters

points – A (3, *n*) array containing the random X,Y, Z points to be gridded.

grid_x – The X dimension of the grid. The X values are scaled to fit this dimension.

grid_y – The Y dimension of the grid. The Y values are scaled to fit this dimension.

Returned Value

result – A gridded, 2D array containing Z values.

Input Keywords

Iter – The number of iterations on the smooth function. The execution time increases linearly with the number of iterations. The default is 3, but any non-negative integer (including zero) may be specified.

Nghbr – The size of the neighborhood to smooth. If not supplied, the neighborhood size is calculated from the distribution of the points. The amount of memory required increases by the square of the neighborhood size.

No_Avg – Normally, if multiple data points fall in the same cell in the gridded array, then the value of that cell is the average value of all the data points that fall in that cell.

If the *No_Avg* keyword is present and nonzero, however, the value of the cell in the gridded array is the total of all the points that fall in that cell.

XMin – The X coordinate of the left edge of the grid. If omitted, maps the minimum X value found in the *points(0, *)* array to the left edge of the grid.

XMax – The X coordinate of the right edge of the grid. If omitted, maps the maximum X value found in the *points(0, *)* array to the right edge of the grid.

YMin – The Y coordinate of the bottom edge of the grid. If omitted, maps the minimum Y value found in the *points(1, *)* array to the bottom edge of the grid.

YMax – The Y coordinate of the top edge of the grid. If omitted, maps the maximum Y value found in the *points(1, *)* array to the top edge of the grid.

Discussion

FAST_GRID3 uses a neighborhood smoothing technique to interpolate missing data values for 3D gridding. The gridded array returned by FAST_GRID3 is suitable for use with the SURFACE, TV, AND CONTOUR procedures.

FAST_GRID3 is similar to GRID_3D. FAST_GRID3, however, works best with dense data points (more than 1000 points to be gridded) and is considerably faster, but slightly less accurate, than GRID_3D. (GRID_3D works best with sparse data points and is stable when extrapolating into large void areas.)

Tip For best results, use a small neighborhood (such as 3) and a large number of iterations (more than 16).

Examples

```
PRO f_gridemo3
```

This program shows 3D gridding with dense data points.

```
points = RANDOMU(s, 3, 1000)
points(0, *) = points(0, *) * 10.0
points(1, *) = points(1, *) * 10.0
points(*, 0) = [1.7, 1.6,   2.9]
points(*, 1) = [1.4, 1.2,   3.7]
points(*, 2) = [9.8, 9.2,   5.5]
points(*, 3) = [9.8, 8.4,   0.1]
points(*, 4) = [4.8, 9.9,   6.3]
points(*, 5) = [0.2, 9.0,   9.0]
points(*, 6) = [3.1, 7.2,  15.2]
points(*, 7) = [5.6, 6.0,  -5.9]
points(*, 8) = [0.3, 0.5,   3.3]
points(*, 9) = [9.7, 0.7,  -1.6]
```

Generate random data points.

```
zval = FAST_GRID3(points, 48, 32)
```

Grid the resulting data points.

```
WINDOW, 0, Colors=128
SURFR
SURFACE, zval, Bottom=90, Ax=30.0, Az=30.0, $
   /T3d
```

Display the gridded data as a surface in the specified window.

```
END
```

See Also

GRID_2D, GRID_3D, GRID_4D, GRID_SPHERE, FAST_GRID2, FAST_GRID4

For information on the optional software package for advanced gridding, PV-WAVE:GTGRID, contact your Visual Numerics account representative.

FAST_GRID4 Function

Returns a gridded, 3D array containing intensity values, given random 4D coordinates (this function works best with dense data points).

Usage

result = FAST_GRID4(*points, grid_x, grid_y, grid_z*)

Input Parameters

points – A (4, *n*) array containing the random 4D points to be gridded. Typically, *points(0, *)* contains the X values, *points(1, *)* contains the Y values, *points(2, *)* contains the Z values, and *points(3, *)* contains the intensity values. (You may, however, choose to put other variables in these four vectors.)

grid_x – The X dimension of the grid. The X values are scaled to fit this dimension.

grid_y – The Y dimension of the grid. The Y values are scaled to fit this dimension.

grid_z – The Z dimension of the grid. The Z values are scaled to fit this dimension.

Returned Value

result – A gridded, 3D array containing intensity values.

Input Keywords

Iter – The number of iterations on the smooth function. The execution time increases linearly with the number of iterations. The default is 3, but any non-negative integer (including zero) may be specified.

Nghbr – The size of the neighborhood to smooth. If not supplied, the neighborhood size is calculated from the distribution of the points. The amount of memory required increases by the square of the neighborhood size.

No_Avg – Normally, if multiple data points fall in the same cell in the gridded array, then the value of that cell is the average value of all the data points that fall in that cell.

If the *No_Avg* keyword is present and nonzero, however, the value of the cell in the gridded array is the total of all the points that fall in that cell.

XMin – The X coordinate of the left edge of the grid. If omitted, maps the minimum X value found in the *points(0, *)* array to the left edge of the grid.

XMax – The X coordinate of the right edge of the grid. If omitted, maps the maximum X value found in the *points(0, *)* array to the right edge of the grid.

YMin – The Y coordinate of the bottom edge of the grid. If omitted, maps the minimum Y value found in the *points(1, *)* array to the bottom edge of the grid.

YMax – The Y coordinate of the top edge of the grid. If omitted, maps the maximum Y value found in the *points(1, *)* array to the top edge of the grid.

ZMin – The Z coordinate of the back edge of the grid. If omitted, maps the minimum Z value found in the *points(2, *)* array to the back edge of the grid.

ZMax – The Z coordinate of the front edge of the grid. If omitted, maps the maximum Z value found in the *points(2, *)* array to the front edge of the grid.

Discussion

FAST_GRID4 uses a neighborhood smoothing technique to interpolate missing data values for 4D gridding. The gridded array returned by FAST_GRID4 is suitable for use with the SHADE_VOLUME and VOL_REND functions.

FAST_GRID4 is similar to GRID_4D. FAST_GRID4, however, works best with dense data points (more than 1000 points to be gridded) and is considerably faster, but slightly less accurate, than GRID_4D. (GRID_4D works best with sparse data points and is stable when extrapolating into large void areas.)

Tip For best results, use a small neighborhood (such as 3) and a large number of iterations (more than 16).

Examples

See the Examples section in the description of the CENTER_VIEW routine.

See Also

GRID_2D, GRID_3D, GRID_4D, GRID_SPHERE, FAST_GRID3

For information on the optional software package for advanced gridding, PV-WAVE:GTGRID, contact your Visual Numerics account representative.

FFT Function

Returns the Fast Fourier Transform for the input variable.

Usage

result = FFT(*array, direction*)

Input Parameters

array — The array for which the FFT or reverse FFT is computed. The size of each dimension may be any integer value.

direction — A signed scalar value that determines the direction of the transform, between the time (or spatial) domain and the frequency domain.

Returned Value

result — The Fast Fourier Transform of *array*. The Cooley-Tukey Fast Fourier Transform algorithm is used for calculating the FFT.

Keywords

None.

Discussion

The Fourier transform of a scaled-time function is defined by:

$$Fw = Ffat = \int_{-\infty}^{\infty} fate^{-jwt} dt$$

where *w* relates to the frequency domain, and *t* relates to the time (space) domain.

The data type of *array* is converted to complex, with the real part described by *array* and the imaginary part set to 0, unless it is already complex. The output array will have the same number and size of dimensions as *array*.

Tip For more efficient transforms, choose dimensions for *array* that are a power of 2.

The *direction* parameter controls the direction of the transform:

- Set *direction* to a negative value to transform from space to frequency.
- Set *direction* to a positive (or zero) value to go from frequency to space.

A normalization factor of 1/*n*, where *n* is the number of points in *array*, is applied to the transformation when going from space to frequency.

Caution Take care to avoid wrap-around artifacts when filtering and convolving in the frequency domain. In particular, make sure your images are properly windowed and sampled before applying the Fast Fourier Transform, or false and misleading values will result.

Example 1

This example shows what an aerial image looks like before and after applying the FFT function, in conjunction with other PV-WAVE functions.

The FFT function is used to transform the image into the frequency domain. For the example shown in Figure 2-15, the following parameters are used:

```
fft_aerial = FFT(aerial_img, -1)
```

FFT places the frequency component into the first element of the image, which appears in the lower-left corner. However, it is customary to display Fourier spectra of images with the frequency component in the center of the image. This can be done using the SHIFT function to move the origin to the center, and the ABS and ALOG functions to convert the data back into a format that can be displayed:

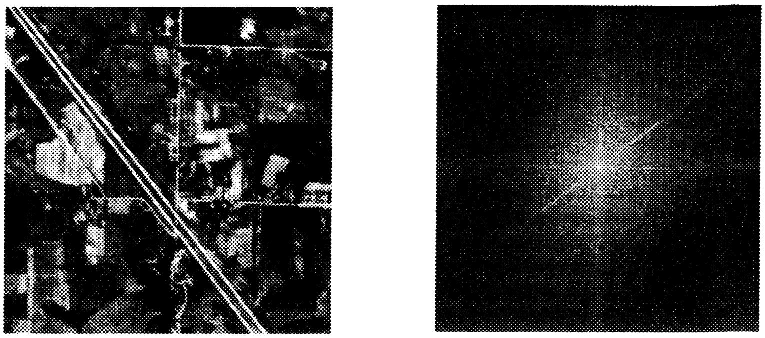


Figure 2-15 PV-WAVE makes it easy to generate the Fourier spectrum for any image. Note that the diagonal, vertical, and horizontal lines in the Fourier spectrum correspond to the roads in the original 512-by-512 image, but are perpendicular to them; this is because of the 90-degree phase shift that occurs when moving from the space domain to the frequency domain.

- Use the SHIFT function to shift the image so the point with a subscript of (0,0) is in the center (assuming the image is a 512-by-512 image).
- Use the ALOG function to return the natural logarithm of each pixel.
- Use the ABS function to calculate the magnitude of each complex-valued pixel.

The result of the initial FFT operation (`fft_aerial`) can be run through these other three functions as follows:

```
display = SHIFT(ALOG(ABS(fft_aerial)), $
   256, 256)
```

The resulting variable, `display`, is the image displayed on the right in Figure 2-15.

Example 2

For an example of an FFT used in windowing, see the description of the HANNING function.

See Also

HANNING, HILBERT

For background information, see *Frequency Domain Techniques* on page 162 of the *PV‑WAVE User's Guide.*

For details on the Cooley-Tukey Fast Fourier Transform algorithm, see the Special Issue on FFT in *IEEE Audio Transactions*, June 1967.

FILEPATH Function

Standard Library function that returns the file path to use to open a PV‑WAVE file, when given a file name within the PV‑WAVE distribution.

Optionally, can also return the file name of the user's terminal and the default location for temporary files for the current operating system.

Usage

result = FILEPATH(*filename*)

Input Parameters

filename – A string containing the name of a file. Must be in all lowercase. Do not enter any device or directory information.

Returned Value

result – The fully qualified file path for *filename.*

Input Keywords

Subdirectory – The name of the subdirectory in the PV-WAVE distribution area in which *filename* is located.

Output Keywords

Terminal – The file name of the user's terminal.

Tmp – The path to the default location for temporary files for the current operating system (*filename* is a temporary or "scratch" file).

Discussion

FILEPATH is used to get path information for a file. It is not a search facility, but simply builds the file path by padding information based on the operating system and keyword information passed into the function in the system variable !Dir.

FILEPATH does not check for the existence of *filename*, but rather only contracts a fully qualified pathname. It does account for operating system dependencies.

This routine is useful when you are writing a procedure that will be used on both UNIX and VMS and will open files in the PV-WAVE distribution.

UNIX Examples

```
PRINT, filepath('wvstartup')
   /usr/local/pvi/wave/wvstartup

full_name = FILEPATH('errplot', $
   Subdirectory='lib/std')
PRINT, full_name
   /usr/local/pvi/wave/lib/std/errplot

PRINT, FILEPATH('dummy',/Terminal)
   /dev/tty

PRINT, FILEPATH('scratch10',/Tmp)
   /tmp/scratch10
```

VMS Examples

```
PRINT, filepath('wvstartup')
   WAVE_DIR:[000000]wvstartup

full_name = FILEPATH('errplot', $
   Subdirectory='lib.std')
PRINT, full_name
   WAVE_DIR:[lib.std]errplot

PRINT, FILEPATH('dummy',/Terminal)
   SYS$OUTPUT:

PRINT, FILEPATH('scratch10',/Tmp)
   SYS$LOGIN:scratch10
```

See Also

FINDFILE, !Dir, !Path

FINDFILE Function

Returns a string array containing the names of all files matching a specified file description.

Usage

result = FINDFILE(*file_specification*)

Input Parameters

file_specification — A scalar string used to find files. May contain any valid shell wildcard characters. If omitted, all files in the current directory are supplied.

Returned Value

result — A string array containing the names of all files matching *file_specification*. If no files with matching names exist, returns a null scalar string.

Output Keywords

Count – A named variable into which the number of files found is placed. A value of 0 indicates that no files were found.

Discussion

FINDFILE returns all matched filenames in a string array, one file name per array element.

Under UNIX, FINDFILE uses the shell specified by the `SHELL` environment variable (or `/bin/sh` if `SHELL` is not defined) to search for any files matching *file_specification.*

UNDER VMS, FINDFILE uses the command language interpreter.

Example

This example assumes you have two files, `test.c` and `test_2.c`, in your current directory.

```
x=FINDFILE('*.c', Count=cntr)
PRINT, x
   test.c   test_2.c
PRINT, cntr
   2
```

See Also

FILEPATH

FINDGEN Function

Returns a single-precision floating-point array with the specified dimensions.

Usage

result = FINDGEN*(dim$_1$, ..., dim$_n$)*

Input Parameters

dim$_i$ – The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result – An initialized single-precision, floating-point array. If the resulting array is treated as a one-dimensional array, then its initialization is given by the following:

$$array\,(i) = \mathrm{FLOAT}\,(i), \text{ for } i = 0, 1, \ldots, \left(\prod_{j=1}^{n} D_j - 1\right)$$

Keywords

None.

Discussion

Each element of the array is set to the value of its one-dimensional subscript.

Example

This example creates a 4-by-2 single-precision, floating-point array.

```
a = FINDGEN(4, 2)
```
Create single-precision, floating-point array.

```
INFO, a
A          FLOAT          = Array(4, 2)

PRINT, a
0.00000    1.00000    2.00000    3.00000
4.00000    5.00000    6.00000    7.00000
```

See Also

BINDGEN, CINDGEN, DINDGEN, INDGEN, LINDGEN, SINDGEN

FINITE Function

Returns a value indicating if the input variable is finite or not.

Usage

result = FINITE(*x*)

Input Parameters

x – A scalar or array expression of complex, single- or double-precision floating-point data type.

Returned Value

result – Returns 1 if *x* is finite. Returns 0 if *x* is infinite or not a defined number (NaN). Undefined numbers result from ill-defined operations, such as dividing zero by zero, or taking the logarithm of zero or a negative number.

Keywords

None.

Example

```
fmach = MACHINE(/Float)
```

Get the single-precision, floating-point machine constants.

```
a = [fmach.nan, 3.0, fmach.pos_inf, 5.2,$
    fmach.neg_inf]
```

Create a five-element vector containing single-precision, floating-point NaN, positive infinity, negative infinity, and finite values.

```
b = FINITE(a)
```

View result of FINITE.

```
INFO, b
B           BYTE         = Array(5)

FOR i = 0, 4 DO PRINT, a(i), b(i)

NaN        0
3.00000    1
Inf        0
5.20000    1
-Inf       0
```

Print vectors a and b. Note that vector b contains a 0 when NaN or infinity occurs in a. Vector b contains a 1 at the indices where vector a contains finite values.

See Also

ON_ERROR, ON_IOERROR, CHECK_MATH

For more information, see Chapter 10, *Programming with PV-WAVE*, in the *PV-WAVE Programmer's Guide.*

FIX Function

Converts an expression to integer data type.

Extracts data from an expression and places it in a integer scalar or array.

Usage

result = FIX(*expr*)

This form is used to convert data.

result = FIX(*expr, offset, dim_1* [, ..., *dim_n*])

This form is used to extract data.

Input Parameters

expr – The expression to be converted, or from which to extract data.

offset – (Used to extract data only.) The offset, in bytes, from the beginning of *expr* to where the extraction is to begin.

dim_i – (Used to extract data only.) The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result – (For data conversion.) A copy of *expr* converted to integer data type. If no *dim_i* parameters are specified, *result* has the same structure as *expr.*

(For data extraction.) If *offset* is used, FIX does not convert *result,* but allows fields of data extracted from *expr* to be treated as integer data.

Keywords

None.

Discussion — Conversion Usage

Caution If the values of *expr* are within the range of a long integer, but outside the range of the integer data type (–32,768 to +32,767), a misleading result occurs, without an accompanying message. For example, `FIX(66000)` erroneously results in 464.

In addition, PV-WAVE does not check for overflow during conversion to integer data type. The values in *expr* are simply converted to long integers and the low 16 bits are extracted.

Examples

In this example, FIX is used in two ways. First, FIX is used to convert a single-precision, floating- point array to integer. Next, FIX is used to extract a subarray from the integer array created in the first step.

```
a = FINDGEN(6) + 0.6
```

Create a single precision, floating point vector of length 6. Each element has a value equal to its one-dimensional subscript plus 0.6.

```
PRINT, a
0.600000 1.60000 2.60000 3.60000 4.60000
 5.60000
```

```
b = FIX(a)
```

Convert a to type integer.

```
INFO, b
B          INT        = Array(6)
```

Notice that the floating-point numbers in a were truncated by FIX.

```
PRINT, b
0    1    2    3    4    5
```

```
c = FIX(b, 4, 2, 2)
```

Extract the last four elements of b, and place them in a 2-by-2 integer array.

```
INFO, c
C           INT         = Array(2, 2)
PRINT, c
2         3
   4         5
```

See Also

BYTE, COMPLEX, DOUBLE, FLOAT, LONG

For more information on using this function to extract data, see *Extracting Fields* on page 37 of the *PV-WAVE Programmer's Guide.*

FLOAT Function

Converts an expression to single-precision floating-point data type.

Extracts data from an expression and places it in a single-precision floating-point scalar or array.

Usage

result = FLOAT(*expr*)

This form is used to convert data.

result = FLOAT(*expr, offset, dim*$_1$ [, ..., *dim*$_n$])

This form is used to extract data.

Input Parameters

expr – The expression to be converted, or from which to extract data.

offset – (Used to extract data only.) The offset, in bytes, from the beginning of *expr* to where the extraction is to begin.

dim_i – (Used to extract data only.) The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result – (For data conversion.) A copy of *expr* converted to single-precision floating-point data type. If no dim_i parameters are specified, *result* has the same size and number of dimensions as *expr*.

(For data extraction.) If *offset* is used, FLOAT does not convert *result*, but allows fields of data extracted from *expr* to be treated as single-precision floating-point data.

Keywords

None.

Example

In this example, FLOAT is used in two ways. First, FLOAT is used to convert an integer array to single precision, floating point. Next, FLOAT is used to extract a subarray from the single-precision array created in the first step.

```
a = INDGEN(6)
```

Create an integer vector of length 6. Each element has a value equal to its one-dimensional subscript.

```
PRINT, a
0    1    2    3    4    5
```

```
b = FLOAT(a)
```

Convert a to single precision, floating point.

```
INFO, b
B          FLOAT          = Array(6)
```

```
PRINT, b
0.00000 1.00000  2.00000 3.00000 4.00000
5.00000
```

```
c = FLOAT(b, 8, 2, 2)
```

Extract the last four elements of b, and place them in a 2-by-2 single-precision, floating-point array.

```
INFO, c
C             FLOAT          = Array(2, 2)

PRINT, c
2.00000       3.00000
4.00000       5.00000
```

See Also

BYTE, COMPLEX, DOUBLE, FIX, LONG

For more information on using this function to extract data, see *Extracting Fields* on page 37 of the *PV-WAVE Programmer's Guide.*

FLTARR Function

Returns a single-precision floating-point vector or array.

Usage

result = FLTARR(*dim*$_1$, ..., *dim*$_n$)

Input Parameters

dim$_i$ — The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result — A single-precision floating-point vector or array.

Input Keywords

Nozero — Normally, FLTARR sets every element of *result* to zero. If *Nozero* is nonzero, this zeroing is not performed, thereby causing FLTARR to execute faster.

Example

```
PRINT, FLTARR(4)
   0.00000    0.00000    0.00000    0.00000

PRINT, FLTARR(4, /Nozero)
   5.60519e-45  1.98225e-39  2.35149e-38
      5.60519e-45
```

See Also

BYTARR, COMPLEXARR, DBLARR, FINDGEN, INTARR, LONARR, MAKE_ARRAY, REPLICATE, STRARR

FLUSH Procedure

Causes all buffered output on the specified file units to be written.

Usage

FLUSH, *unit*$_1$, ..., *unit*$_n$

Input Parameters

unit$_i$ – The PV-WAVE file units (logical unit numbers) to flush.

Keywords

None.

Discussion

PV-WAVE uses buffered output for reasons of efficiency. This leads to rare occasions where a program needs to be certain that output data are not waiting in a buffer, but have actually been output. This procedure is handy for such occasions.

See Also

CLOSE, EMPTY

For background information, see Chapter 8, *Working with Data Files*, in the *PV-WAVE Programmer's Guide.*

FREE_LUN Procedure

Deallocates file units previously allocated with GET_LUN.

Usage

FREE_LUN, *unit*$_1$, ..., *unit*$_n$

Input Parameters

unit$_i$ – The PV-WAVE file units (logical unit numbers) to deallocate.

Keywords

None.

Discussion

If the specified file units are open, they are closed prior to the deallocation process.

Example

Suppose that the first available logical unit number is 100.

```
GET_LUN, log_unit
```

Returns the logical unit number to allocate (100).

```
OPENR, log_unit, 'test.dat'
```

Open test.dat file for reading.

```
READF, log_unit, my_var
```

Read the file.

```
FREE_LUN, log_unit
```

Closes the file and frees the logical unit 100.

See Also

CLOSE, GET_LUN, POINT_LUN

For background information, see *Logical Unit Numbers (LUNs)* on page 141 of the *PV-WAVE Programmer's Guide.*

FSTAT Function

Returns an expression containing status information about a specified file unit.

Usage

result = FSTAT(*unit*)

Input Parameters

unit – The PV-WAVE file unit (logical unit number) about which information is required.

Returned Value

result – A structure expression of type FSTAT containing status information about *unit.*

Keywords

None.

Discussion

FSTAT can be used to get more detailed information, as well as information that can be used from within a PV-WAVE program.

Example 1

To get detailed information about the standard input, enter the command:

```
INFO, /Structures, FSTAT(0)
```

This causes the following to be displayed on the screen:

```
** Structure FSTAT, 10 tags, 32 length:
UNIT               LONG          0
NAME               STRING    '<stdin>'
OPEN               BYTE          1
ISATTY             BYTE          1
READ               BYTE          1
WRITE              BYTE          0
TRANSFER_COUNT     LONG          0
CUR_PTR            LONG       8112
SIZE               LONG          0
REC_LEN            LONG          0
```

The fields of the FSTAT structure provide the following information:

UNIT – The PV-WAVE file unit number.

NAME – The name of the file.

OPEN – Nonzero if the file unit is open. If OPEN is 0, the remaining fields in FSTAT will not contain useful information.

ISATTY – Nonzero if the file is actually a terminal instead of a normal file.

READ – Nonzero if the file is open for read access.

WRITE – Nonzero if the file is open for write access.

TRANSFER_COUNT – The number of scalar PV-WAVE data items transferred in the last I/O operation on the unit. This is set by the following PV-WAVE routines: READ, READF, READU, PRINT, PRINTF, and WRITEU.

TRANSFER_COUNT is useful when you are attempting to recover from input/output errors.

CUR_PTR – The current position of the file pointer, given in bytes from the start of the file. If the device is a terminal (ISATTY is nonzero), the value of CUR_PTR will not contain useful information.

SIZE – The current length of the file, in bytes. If the device is a terminal (`ISATTY` is nonzero), the value of `SIZE` will not contain useful information.

REC_LEN – VMS-specific record length, in bytes. This field is always zero in UNIX.

Example 2

The following PV-WAVE function can be used to read single-precision floating point data from a file into a vector when the number of elements in the file is not known. This function uses FSTAT to get the size of the file in bytes and then divides by 4 (the size of a single-precision floating-point value) to determine the number of values:

```
FUNCTION read_data, file
```

Read_data reads all the floating-point values from file and returns the result as a floating-point vector.

```
OPENR, /Get_Lun, unit, file
```

Get a unique file unit and open the data file.

```
status = FSTAT(unit)
```

Retrieve the file status.

```
data = FLTARR(status.size / 4.0)
```

Make an array to hold the input data. The size tag of status gives the number of bytes in the file and single-precision floating-point values are four bytes each.

```
READU, unit, data
```

Read the data.

```
FREE_LUN, unit
```

Deallocate the file unit and close the file.

```
RETURN, data
```

Return the data.

```
END
```

This is the end of the read_data function.

Assuming that a file named `herc.dat` exists and contains 10 floating-point values, the following PV-WAVE statements:

```
a = read_data('herc.dat')
```

Read floating-point values from herc.dat.

```
INFO, a
```

Show the result.

will produce the following output:

```
A                FLOAT     = Array(10)
```

See Also

POINT_LUN, GET_LUN, FREE_LUN, CLOSE, OPENR, OPENU, OPENW

For more information, see *Getting Information About Files* on page 220 of the *PV-WAVE Programmer's Guide.*

For background information, see *Logical Unit Numbers (LUNs)* on page 141 of the *PV-WAVE Programmer's Guide.*

FUNCT Procedure

Standard Library procedure that evaluates a function that is a sum of a Gaussian and a second order polynomial.

Usage

FUNCT, *x*, *parms*, *funcval* [, *pder*]

Input Parameters

x — The values of the independent variable.

parms — The parameters of the equation described in the Discussion section below.

funcval — The value of the function, described in the Discussion section below, at each *x(i)*.

Output Parameters

pder — An N_ELEMENT(*x*)-by-6 array containing the partial derivatives of the function. The parameter *pder(i, j)* is equal to the derivative at the i^{th} point with respect to the j^{th} parameter.

Keywords

None.

Discussion

FUNCT is used primarily by the CURVEFIT function to fit the sum of a line and a varying background to actual data. The function to be evaluated is:

$$F(x) = A_0 e^{(-z^2/2)} + A_3 + A_4 x + A_5 x^2$$

where

$$z = (x - A_1) / (a_2)$$

See Also

CURVEFIT

GAMMA Function

Calculates the gamma function of the input variable.

Usage

result = GAMMA(*x*)

Input Parameters

x — The expression for which the gamma function will be evaluated. *x* must evaluate to < 34.5; otherwise, a floating-point overflow will result.

Returned Value

result — The gamma function of *x*. The result is floating-point, regardless of the data type for *x*.

Keywords

None.

Discussion

The gamma function can be used in a variety of applications; one example is to solve nonlinear flow problems, such as the creep of metals.

GAMMA is defined as:

$$\Gamma(x) = \int_0^{\infty} t^{x-1} e^{-t} dt \qquad x > 0$$

The gamma function has the following properties:

$$\Gamma(x+1) = x\Gamma(x)$$

A special value of the gamma function occurs when $x = 1/2$:

$$\Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$$

See Also

ERRORF, GAUSSINT

GAUSSFIT Function

Standard Library function that fits a Gaussian curve through a data set.

Usage

result = GAUSSFIT(*x*, *y* [, *coefficients*])

Input Parameters

x – A real vector containing the values of the independent variable.

y – A real vector containing the values of the dependent variable. Should be the same length as *x*.

Output Parameters

coefficients – A six-element vector with the coefficients A_0 through A_5 of the equation described in the Discussion section below.

Returned Value

result – A real vector containing the dependent Y values of the fitted function.

Keywords

None.

Discussion

GAUSSFIT fits y = F(x), where:

$$F(x) = A_0 * EXP(-z^2/2) + A_3 + A_4x + A_5x^2$$

and where

$$z = z(x - A_1)/(A_2)$$

GAUSSFIT calls the POLY_FIT function to fit a straight line through the data for the purpose of determining estimates of the height, center, orientation, and width (approximately 1/e) of the Gaussian function to be fitted to the data.

These estimated parameters — along with the constant, linear, and quadratic coefficients of the straight line polynomial — are sent to the CURVEFIT function as trial coefficients of the Gaussian function. CURVEFIT uses a nonlinear least-squares method to fit a function with an arbitrary number of parameters. Any nonlinear function can be fitted as long as the partial derivatives of the function are known or can be approximated.

The peak or minimum of the Gaussian function returned will be located at the index of the largest or smallest value, respectively, in the Y vector.

See Also

CURVEFIT, POLY_FIT, GAUSSINT

GAUSSINT Function

Evaluates the integral of the Gaussian probability function.

Usage

result = GAUSSINT(*x*)

Input Parameters

x – The expression for which the Gaussian function is computed. Can be a scalar or array expression of any type except string.

Returned Value

result – The integral of the Gaussian probability function. Yields floating-point results, regardless of the data type of *x*. Scalar inputs yield scalar results, and array inputs yield array results.

Keywords

None.

Discussion

The Gaussian probability function provides a good mathematical model for many different physically observed random phenomema. It can easily be extended to handle an arbitrarily large number of random variables. It is most commonly associated with the standard bell-shaped curve.

GAUSSINT is defined by:

$$Gaussint\ (x) \equiv \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{(-t^2)/2} dt$$

See Also

ERRORF, GAMMA, GAUSSFIT

GETENV Function

Returns the specified equivalence string from the environment of the PV-WAVE process.

Usage

result = GETENV(*name*)

Input Parameters

name – The scalar for which an equivalence string from the environment is desired.

Returned Value

result – The equivalence string for *name*. If *name* does not exist in the environment, returns a null string.

Keywords

None.

Discussion – VMS Usage

VMS does not directly support the concept of environment variables. Instead, it is emulated in the manner described below, which allows you to use GETENV portably between UNIX and VMS:

- If *name* is one of `HOME`, `TERM`, `PATH`, or `USER`, an appropriate response is generated. This mimics the most common UNIX environment variables.
- An attempt is made to translate *name* as a logical name. All four logical name tables are searched in the standard order.
- An attempt is made to translate *name* as a command-language interpreter symbol.

Example 1

This PV-WAVE command prints information about the environment:

```
PRINT, 'Current shell is: ', GETENV('SHELL')
```

Example 2

This example shows how to read data from a file in a manner that will work on either UNIX or VMS systems:

```
IF !Version.platform EQ 'VMS' THEN $
   OPENR, u, GETENV('WAVE_DIR')+$
   '[data]heartbeat.dat', /Get_Lun $

ELSE $
OPENR, u, '$WAVE_DIR/data/heartbeat.dat', $
   /Get_Lun
```

See Also

ENVIRONMENT, SETENV

GET_KBRD Function

Returns the next character available from standard input (PV-WAVE file unit 0).

Usage

result = GET_KBRD(*wait*)

Input Parameters

wait — If *wait* is zero, GET_KBRD returns the null string if there are no characters in the terminal typeahead buffer. If it is nonzero, GET_KBRD waits for a character to be typed before returning.

Returned Value

result — The next character available from standard input, as a one-character string.

Keywords

None.

Example

In this example, a character is read from the keyboard, and the character and its ASCII code are echoed to the screen. The loop is terminated when "q" or "Q" is typed.

```
REPEAT BEGIN &$
```

Retrieve keyboard input, placing result in the variable a.

```
a = GET_KBRD(1) &$
PRINT, a,' = ', BYTE(a) &$
ENDREP UNTIL STRLOWCASE(a) EQ 'q'
```

Display the character entered and its associated ASCII code. Terminate loop when "q" or "Q" is entered.

GET_LUN Procedure

Allocates a file unit from a pool of free units.

Usage

GET_LUN, *unit*

Input Parameters

unit – A named variable.

Output Parameters

unit – On output, *unit* is converted into an integer containing the PV-WAVE file unit number.

Keywords

None.

Discussion

GET_LUN sets *unit* to the first available logical unit number. This number can then be used to open a file.

User-written PV-WAVE functions and procedures should use GET_LUN to reserve unit numbers to avoid conflicts with other routines. (Similarly, they should use FREE_LUN to free them when finished).

Note The *Get_Lun* keyword, used with the OPENR, OPENU, and OPENW procedures, calls GET_LUN to allocate a file unit number.

Example

Suppose that the first available logical unit number is 100.

```
GET_LUN, log_unit
```
Returns the logical unit number to allocate (100).

```
OPENR, log_unit, 'test.dat'
```
Open test.dat file for reading.

```
READF, log_unit, my_var
```
Read the file.

```
FREE_LUN, log_unit
```
Closes the file and frees the logical unit 100.

See Also

FREE_LUN, POINT_LUN, OPENR, OPENU, OPENW, READF, WRITEU, CLOSE, ON_IOERROR

For background information, see *Logical Unit Numbers (LUNs)* on page 141 of the *PV-WAVE Programmer's Guide.*

GET_SYMBOL Function

(VMS Only) Returns the value of a VMS DCL interpreter symbol as a scalar string.

Usage

result = GET_SYMBOL(*name*)

Input Parameters

name – A scalar string containing the name of the symbol to be translated.

Returned Value

result – A scalar string containing the value of a VMS Digital Command Language interpreter symbol. If the symbol is undefined, the null string is returned.

Output Keywords

Type – Indicates in which VMS table *name* is found:

1 Specifies the local symbol table (the default).

2 Specifies the global symbol table.

Example

This example assumes that on your system `kermit` is a symbol that points to the KERMIT communications software.

```
my_kermit=GET_SYMBOL('kermit')
```

This converts my_kermit into the string SYS$SYSTEM:KERMIT.

See Also

DELETE_SYMBOL, DELLOG, SETLOG, SET_SYMBOL, TRNLOG

GRID Function

Standard Library function that generates a uniform grid from irregularly-spaced data.

Usage

result = GRID(*xtmp, ytmp, ztmp*)

Input Parameters

xtmp — The vector containing the X coordinates of the irregularly-spaced input data.

ytmp — The vector containing the Y coordinates of the irregularly-spaced input data.

ztmp — The vector containing the Z coordinates of the irregularly-spaced input data.

Returned Value

result — An array containing the gridded Z values applied to a uniform XY grid.

Input Keywords

Nghbr — The number of neighboring data points to be used in the gridding algorithm. Must be in the range of {3 ... 25}. The default is 3.

Nx — The number of columns in the resulting array. Must be $\leq$ 200.

Ny — The number of rows in the resulting array. Must be $\leq$ 200.

Discussion

GRID accepts irregularly-spaced data from three variables; each variable is a vector that corresponds to the X, Y, or Z direction. All three variables must be the same size. GRID returns an evenly-spaced two-dimensional array.

Specifying the number of rows and columns in the resulting array is optional. However, keep the following guidelines in mind:

- If *nx* is not specified, but *ny* is specified, then *nx* is equal to *ny*.
- If *ny* is not specified, but *nx* is specified, then *ny* is equal to *nx*.
- If neither *nx* nor *ny* is specified, then *nx* and *ny* default to 20.

Increasing the value of the *Nghbr* keyword increases the accuracy of the GRID result, but will take longer to compute.

GRID can be used to prepare irregularly-spaced data so that it can be successfully displayed using either the SURFACE or CONTOUR procedures. The X and Y vectors contain the independent data, and the Z vector contains the dependent data that determines the height of the surface or the spacing of the contour lines.

There are several gridding algorithms that grid irregularly spaced data. The algorithm used by GRID works well on some types of data, but not for all.

Note PV-WAVE:GTGRID is an optional software package for advanced gridding. It gives you additional interpolation and extrapolation power by providing access to a library of gridding routines provided by Geophysical Techniques, Inc. For information on PV-WAVE:GTGRID, contact your Visual Numerics account representative.

Example

```
z = MAKE_ARRAY(100, /Index)
x = SIN(z/5) / EXP(z/40)
y = COS(z/5) / EXP(z/40)
SURFACE, DIST(2), XRange=[MIN(x), MAX(x)],$
   Yrange=[MIN(y), MAX(y)], ZRange=[MIN(z),$
   MAX(z)], /Nodata, /Save
```

```
PLOTS, x, y, z, /T3D
result = GRID(x, y, z, Nx=100, Ny=100)
LOADCT, 3
SURFACE, result
SHADE_SURF, result
```

See Also

CONTOUR, SURFACE

Source code for additional gridding routines in the Advanced Rendering Library is located in the directory `wave/demo/arl`. For more information, view the `.pro` files for the routines.

GRID_2D Function

Returns a gridded, 1D array containing Y values, given random X,Y coordinates (this function works best with sparse data points).

Usage

result = GRID_2D(*points, grid_x*)

Input Parameters

points — A (2, *n*) array containing the random X,Y points to be gridded.

grid_x — The size of the vector to return.

Returned Value

result — A gridded, 1D array containing Y values.

Input Keywords

Order — The order of the weighting function to use for neighborhood averaging. The default is 2. Points are weighted by the function:

```
w = 1.0 / (dist ^ Order)
```

where `dist` is the distance to the point.

XMin – The X coordinate of the left edge of the grid. If omitted, maps the minimum X value found in the *points(0, *)* array to the left edge of the grid.

XMax – The X coordinate of the right edge of the grid. If omitted, maps the maximum X value found in the *points(0, *)* array to the right edge of the grid.

Discussion

GRID_2D uses an inverse distance averaging technique to interpolate missing data values for 2D gridding. The gridded array returned by GRID_2D is suitable for use with the PLOT function.

GRID_2D is similar to FAST_GRID2. GRID_2D, however, works best with sparse data points (say, less than 1000 points to be gridded) and is stable when extrapolating into large void areas. (FAST_GRID2 works best with dense data points; it is considerably faster, but slightly less accurate, than GRID_2D.)

Examples

```
PRO grid_demo2
```

This program shows 2D gridding with sparse data points.

```
points = INTARR(2, 10)
points(*, 0) = [1,2]
points(*, 1) = [1,3]
points(*, 2) = [9,5]
points(*, 3) = [8,0]
points(*, 4) = [9,6]
points(*, 5) = [9,9]
points(*, 6) = [7,15]
points(*, 7) = [6,-5]
points(*, 8) = [0,3]
points(*, 9) = [0,-1]
```

Generate the data.

```
WINDOW, 0, Colors=128
LOADCT, 4
T3D, /Reset
```

Reset the viewing window and load the color table.

```
!Y.Range = [MIN(points), MAX(points)]
```

Set the Y axis range for plotting.

```
yval = GRID_2D(points, 256, Order=0.5)
PLOT, yval, Color=60
yval = GRID_2D(points, 256, Order=1.0)
OPLOT, yval, Color=80
yval = GRID_2D(points, 256, Order=2.0)
OPLOT, yval, Color=100
yval = GRID_2D(points, 256, Order=3.0)
OPLOT, yval, Color=120
```

Grid and plot the resulting data.

```
!Y.Range = [0.0, 0.0]
```

Reset the Y axis range to the default value.

```
END
```

See Also

GRID_3D, GRID_4D, GRID_SPHERE, FAST_GRID2, FAST_GRID3, FAST_GRID4

For information on the optional software package for advanced gridding, PV-WAVE:GTGRID, contact your Visual Numerics account representative.

GRID_3D Function

Returns a gridded, 2D array containing Z values, given random X, Y, Z coordinates (this function works best with sparse data points).

Usage

result = GRID_3D(*points, grid_x, grid_y*)

Input Parameters

points – A (3, *n*) array containing the random X, Y, Z points to be gridded.

grid_x – The X dimension of the grid. The X values are scaled to fit this dimension.

grid_y – The Y dimension of the grid. The Y values are scaled to fit this dimension.

Returned Value

result – A gridded, 2D array containing Z values.

Input Keywords

Order – The order of the weighting function to use for neighborhood averaging. The default is 2. Points are weighted by the function:

```
w = 1.0 / (dist ^ Order)
```

where `dist` is the distance to the point.

XMin – The X coordinate of the left edge of the grid. If omitted, maps the minimum X value found in the *points(0, *)* array to the left edge of the grid.

XMax – The X coordinate of the right edge of the grid. If omitted, maps the maximum X value found in the *points(0, *)* array to the right edge of the grid.

YMin – The Y coordinate of the bottom edge of the grid. If omitted, maps the minimum Y value found in the *points(1, *)* array to the bottom edge of the grid.

YMax – The Y coordinate of the top edge of the grid. If omitted, maps the maximum Y value found in the *points(1, *)* array to the top edge of the grid.

Discussion

GRID_3D uses an inverse distance averaging technique to interpolate missing data values for 3D gridding. The gridded array returned by GRID_3D is suitable for use with the SURFACE, TV, and CONTOUR procedures.

GRID_3D is similar to FAST_GRID3. GRID_3D, however, works best with sparse data points (say, less than 1000 points to be gridded) and is stable when extrapolating into large void areas. (FAST_GRID3 works best with dense data points; it is considerably faster, but slightly less accurate, than GRID_3D.)

Examples

```
PRO grid_demo3
```

This program shows 3D gridding with sparse data points.

```
points = INTARR(3, 10)
points(*, 0) = [1,1,2]
points(*, 1) = [1,1,3]
points(*, 2) = [9,9,5]
points(*, 3) = [9,8,0]
points(*, 4) = [4,9,6]
points(*, 5) = [0,9,9]
points(*, 6) = [3,7,15]
points(*, 7) = [5,6,-5]
points(*, 8) = [0,0,3]
points(*, 9) = [9,0,-1]
```

Generate the data points.

```
zval = GRID_3D(points, 48, 32, Order=2.0)
```

Grid the data points.

```
WINDOW, 0, Colors=128
SURFR
SURFACE, zval, Bottom=90, Ax=30.0, Az=30.0, $
   /T3d
```

Display the gridded data as a surface.

```
END
```

See Also

GRID_2D, GRID_4D, GRID_SPHERE, FAST_GRID2

FAST_GRID3, FAST_GRID4

For information on the optional software package for advanced gridding, PV-WAVE:GTGRID, contact your Visual Numerics account representative.

GRID_4D Function

Returns a gridded, 3D array containing intensity values, given random 4D coordinates (this function works best with sparse data points).

Usage

result = GRID_4D(*points, grid_x, grid_y, grid_z*)

Input Parameters

points – A (4, *n*) array containing the random 4D points to be gridded. Typically, *points(0, *)* contains the X values, *points(1, *)* contains the Y values, *points(2, *)* contains the Z values, and *points(3, *)* contains the intensity values. (You may, however, choose to put other variables in these four vectors.)

grid_x – The X dimension of the grid. The X values are scaled to fit this dimension.

grid_y – The Y dimension of the grid. The Y values are scaled to fit this dimension.

grid_z – The Z dimension of the grid. The Z values are scaled to fit this dimension.

Returned Value

result – A gridded, 3D array containing intensity values.

Input Keywords

Order – The order of the weighting function to use for neighborhood averaging. The default is 2. Points are weighted by the function:

```
w = 1.0 / (dist ^ Order)
```

where `dist` is the distance to the point.

XMin – The X coordinate of the left edge of the grid. If omitted, maps the minimum X value found in the *points(0, *)* array to the left edge of the grid.

XMax – The X coordinate of the right edge of the grid. If omitted, maps the maximum X value found in the *points(0, *)* array to the right edge of the grid.

YMin – The Y coordinate of the bottom edge of the grid. If omitted, maps the minimum Y value found in the *points(1, *)* array to the bottom edge of the grid.

YMax – The Y coordinate of the top edge of the grid. If omitted, maps the maximum Y value found in the *points(1, *)* array to the top edge of the grid.

ZMin – The Z coordinate of the back edge of the grid. If omitted, maps the minimum Z value found in the *points(2, *)* array to the back edge of the grid.

ZMax — The Z coordinate of the front edge of the grid. If omitted, maps the maximum Z value found in the *points(2, *)* array to the front edge of the grid.

Discussion

GRID_4D uses an inverse distance averaging technique to interpolate missing data values for 4D gridding. The gridded array returned by GRID_4D is suitable for use with the SHADE_VOLUME and VOL_REND functions.

GRID_4D is similar to FAST_GRID4. GRID_4D, however, works best with sparse data points (say, less than 1000 points to be gridded) and is stable when extrapolating into large void areas. (FAST_GRID4 works best with dense data points; it is considerably faster, but slightly less accurate, than GRID_4D.)

Examples

```
PRO grid_demo4
```

This program shows 4D gridding with sparse data points and a cut-away.

```
points = INTARR(4, 10)
points(*, 0) = [1, 1, 2, 86]
points(*, 1) = [1, 1, 3, 44]
points(*, 2) = [9, 9, 5, 37]
points(*, 3) = [5, 4, 7, 99]
points(*, 4) = [4, 0, 6,  9]
points(*, 5) = [0, 9, 9, 32]
points(*, 6) = [3, 5, 5,  2]
points(*, 7) = [6, 6, 5, 55]
points(*, 8) = [0, 0, 5, 66]
points(*, 9) = [9, 0, 0, 44]
```

Generate the data to be used for shading.

```
ival = GRID_4D(points, 32, 32, 32, Order=4.0)
ival = BYTSCL(ival)
```

Grid the generated data.

```
block = BYTARR(30, 30, 30)
block(*, *, *) = 255
block = VOL_PAD(block, 1)
```

Pad the data with zeroes.

```
block(0:16, 0:16, 16:31) = 0
```

Cut away a section of the block by setting the desired elements to zero.

```
WINDOW, 0, Colors=128
LOADCT, 3
CENTER_VIEW, Xr=[0.0, 31.0], $
   Yr=[0.0, 31.0], Zr=[0.0, 31.0], $
   Ax=(-60.0), Az=45.0, Zoom=0.6
```

Set up the viewing window and load the color table.

```
SET_SHADING, Light=[-1.0, 1.0, 0.2]
```

Change the direction of the light source for shading.

```
SHADE_VOLUME, block, 1, vertex_list, $
   polygon_list, Shades=ival, /Low
```

Compute the 3D contour surface.

```
img1 = POLYSHADE(vertex_list, polygon_list, $
   /T3d)
```

Render the cut-away block with light source shading.

```
img2 = POLYSHADE(vertex_list, polygon_list, $
   Shades=ival, /T3d)
```

Render the cut-away block shaded by the gridded data.

```
TVSCL, (FIX(img1) + FIX(img2))
```

Display the resulting composite image of the light source-shaded block and the data-shaded block.

```
END
```

For another example, see the `vol_demo4` demonstration program in `$WAVE_DIR/demo/arl`.

See Also

GRID_2D, GRID_3D, GRID_SPHERE, FAST_GRID2, FAST_GRID3, FAST_GRID4

For information on the optional software package for advanced gridding, PV-WAVE:GTGRID, contact your Visual Numerics account representative.

GRID_SPHERE Function

Returns a gridded, 2D array containing radii, given random longitude, latitude, and radius values.

Usage

result = GRID_SPHERE(*points, grid_x, grid_y*)

Input Parameters

points — A (3, *n*) array containing the random longitude, latitude, and radius coordinates to be gridded.

grid_x — The X dimension of the grid. The longitude values are scaled to fit this dimension (unless the *XMin* or *XMax* keywords are set).

grid_y — The Y dimension of the grid. The latitude values are scaled to fit this dimension (unless the *YMin* or *YMax* keywords are set).

Returned Value

result — A gridded, 2D array containing radius values.

Input Keywords

Degrees — If present and nonzero, reads the input coordinates in degrees instead of in radians.

Order — The order of the weighting function to use for neighborhood averaging. The default is 2. Points are weighted by the function:

```
   w = 1.0 / (dist ^ Order)
```

where `dist` is the distance to the point.

Radius — The radius of the sphere to grid on. The minimum allowable radius is 0.5; the default is 1.0.

With a smaller radius, the data points are closer together and more smoothing occurs. A larger radius causes less smoothing.

XMin — The longitude of the left edge of the grid. Should be in the range –π to +π radians (–180 to +180 degrees). The value is assumed to be in radians unless the *Degrees* keyword is set.

If *XMin* is omitted, then a longitude of –π is mapped to the left edge of the grid.

XMax — The longitude of the right edge of the grid. Should be in the range –π to +π radians (–180 to +180 degrees). The *XMax* value is assumed to be in radians unless the *Degrees* keyword is set.

If *XMax* is omitted, then a longitude of π is mapped to the right edge of the grid.

YMin — The latitude of the bottom edge of the grid. Should be in the range –π/2 to +π/2 radians (–90 to +90 degrees). The *YMin* value is assumed to be in radians unless the *Degrees* keyword is set.

If *YMin* is omitted, then a latitude of –π/2 is mapped to the bottom edge of the grid.

YMax — The latitude of the top edge of the grid. Should be in the range –π/2 to +π/2 radians (–90 to +90 degrees). The *YMax* value is assumed to be in radians unless the *Degrees* keyword is set.

If *YMax* is omitted, then a latitude of π/ 2 is mapped to the top edge of the grid.

Discussion

GRID_SPHERE uses an inverse distance averaging technique to interpolate missing data values. The gridded array returned by GRID_SPHERE is suitable for use with the POLY_SPHERE function.

The longitude values are assumed to be in the range $-\pi$ to $+\pi$ (-180 to $+180$ if the *Degrees* keyword is set). The latitude values are assumed to be in the range $-\pi/2$ to $+\pi/2$ (-90 to $+90$ if the *Degrees* keyword is set).

To grid on a portion of a sphere rather than on an entire sphere, use the *XMin*, *XMax*, *YMin*, and *YMax* keywords.

Examples

```
PRO grid_demo5
```

This program shows spherical gridding.

```
sphere = FLTARR(3, 6)
sphere(*, 0) = [ 33.0, -64.0, 0.2]
sphere(*, 1) = [280.0,   5.0, 1.8]
sphere(*, 2) = [350.0,  41.0, 1.9]
sphere(*, 3) = [310.0,  83.0, 0.3]
sphere(*, 4) = [ 67.0, -16.0, 1.6]
sphere(*, 5) = [133.0, -75.0, 0.2]
sphere(0, *) = sphere(0, *) - 180.0
```

Generate the data — random longitude, latitude, and radius points.

```
sphere = GRID_SPHERE(sphere, 32, 32, $
   /Degrees, Order=4.0, Radius=20.0)
```

Grid the resulting sphere.

```
POLY_SPHERE, sphere, 32, 32, vertex_list, $
   polygon_list
```

Generate the polygons representing the spherical surface.

```
WINDOW, 0, Colors=128, XSize=800, YSize=600
LOADCT, 3
```

```
CENTER_VIEW, Xr=[-2.0, 2.0], Yr=[-2.0, 2.0], $
   Zr=[-2.0, 2.0], Ax=(-40.0), Az=0.0, $
   Zoom=1.0, Winx=800, Winy=600
```

Set up the viewing window and load the color table.

```
SET_SHADING, Light=[-0.5, 0.5, 1.0]
TVSCL, POLYSHADE(vertex_list, $
   polygon_list, /T3d)
```

Specify the shading and display the resulting spherical surface.

```
END
```

For another example, see the `sphere_demo3` demonstration program in `$WAVE_DIR/demo/applications/arl/examples`.

See Also

POLY_SPHERE, GRID_2D, GRID_3D, GRID_4D, FAST_GRID2, FAST_GRID3, FAST_GRID4

For information on the optional software package for advanced gridding, PV-WAVE:GTGRID, contact your Visual Numerics account representative.

HAK Procedure

Standard Library procedure that lets you implement a “hit any key to continue” function.

Usage

HAK

Parameters

None.

Input Keywords

Mesg — Alerts the user that the procedure is momentarily stopped. If set to 1 (the default), the following message is printed on the display screen:

```
Hit any key to continue...
```

Mesg may also be set to an arbitrary string.

Discussion

HAK waits for keyboard input, clears the typeahead buffer, and allows the application to continue. It is used primarily to stop a procedure momentarily — for example, to allow the user to read an explanation screen or view a temporary plot.

Example 1

```
a = INDGEN(200)
PRINT, a
HAK, Mesg='Press a key to go on.'
```

Example 2

```
t = 'When ready, press any key.'
PRINT, a
HAK, Mesg=t
```

See Also

WAIT

HANNING Function

Standard Library function that implements a window function for Fast Fourier Transform signal or image filtering.

Usage

result = HANNING(*col* [, *row*])

Input Parameters

col – The number of columns in the result.

row – The number of rows in the result.

Returned Value

result – The processed result.

Keywords

None.

Discussion

HANNING is a window function for signal or image filtering using a Fast Fourier Transform. By processing data through HANNING before applying FFT, more realistic results can be obtained.

The window calculated by HANNING is basically the first half of a cosine – in other words, only the positive cosine values. When used with only the *col* parameter, HANNING returns a vector of the same length as *col*. The vector starts and ends with zeros and rises to a peak in the center (just as a cosine goes up and then comes back down to zero).

For one dimension, the result of HANNING is determined by the following equation:

$$result(i) = \frac{1}{2}\left(1 - \cos\left(\frac{2\pi i}{n-1}\right)\right)$$

where *n* is the total number of elements described by *row* and *col.*

When used with both the *col* and *row* parameters, HANNING returns an array whose dimensions are the same as these two parameters. The resultant array has zeros around the sides and rises to a peak in the center.

For two dimensions, the result is given by the same equation as above, except *i* is replaced with *i* * *j*, where *i* and *j* are the subscripts for the rows and columns, respectively.

Example

```
OPENR, unit, !Data_dir + 'mandril.img', $
   /Get_lun
```

Open the PV-WAVE mandril demo image file.

```
aa = ASSOC(unit, BYTARR(512, 512))
image = aa(0)
```

Store the image.

```
CLOSE, unit
```

Close the logical unit number.

```
han = HANNING(512, 512)
```

Create the HANNING window.

```
a = FFT(image, -1)
```

Create an FFT of the image without the HANNING window.

```
WINDOW, 0, XSize=512, YSize=512, $
   Title='FFT without HANNING Window Applied'
```

```
TVSCL, SHIFT(ALOG(ABS(a)), 256, 256)
```

Shifting makes it easier to see.

```
b = FFT(image * han, -1)
```

Create an FFT of the image with the HANNING window. This diminishes the effect of the outside edges of the image on the FFT result.

```
WINDOW, 2, Xsize=512, Ysize=512, $
   Title='FFT with HANNING Window Applied'
```

```
TVSCL, SHIFT(ALOG(ABS(b)), 256, 256)
```

Take a look at the result for comparison, and notice that the vertical and horizontal streaking is gone.

See Also

FFT, HILBERT

For details on how processing data through HANNING before applying FFT improves results, see Chapter 5 in *Digital Signal Processing,* by Oppenheim and Schafer, Prentice-Hall, Englewood Cliffs, NJ, 1975.

HILBERT Function

Standard Library function that constructs a Hilbert transformation matrix.

Usage

result = HILBERT(*x* [, *d*])

Input Parameters

x – The vector to be transformed. Can be of either floating-point or complex data type, and can contain any number of elements.

d – A flag to indicate the direction of rotation:

+1	Shifts the vector +90 degrees.
–1	Shifts the vector –90 degrees.

Returned Value

result – The value of the Hilbert transform of *x*. Result is of a complex data type, with the same dimensions as *x*.

Keywords

None.

Discussion

A Hilbert transform is a series of numbers in which all periodic components have been phase-shifted by 90 degrees. Angle shifting is accomplished by multiplying or dividing by the complex number *i = (0.000, 1.000)*.

A Hilbert series has the interesting property that the correlation between it and its own Hilbert transform is mathematically zero.

Note The HANNING function generates a Hilbert matrix by generating the Fast Fourier Transform of the data with the FFT function and shifting the first half of the transform products by +90 degrees and the second half by –90 degrees. The constant elements of the transform are not changed.

The shifted vector is then submitted to the FFT function for the transformation back to the "time" domain. Before it is returned, the output is divided by the number of elements in the vector to correct for the multiplication effect characteristic of the FFT algorithm.

Example

```
a = FINDGEN(1000)
sine_wave = SIN(a/(MAX(a)/(2 * !pi)))
```

Create a sine wave.

```
PLOT, sine_wave
```

Plot the sine wave.

```
OPLOT, HILBERT(sine_wave, -1)
```

Plot the sine wave phase-shifted to the right by 90 degrees.

```
rand = RANDOMN(seed, 1000) * 0.05
```

Create an array of random numbers to mimic a noisy signal.

```
PLOT, rand
```

Plot the random numbers.

```
sandwich = [sine_wave, rand, sine_wave]
```

Sandwich the random data between two sine waves.

```
PLOT, sandwich, XStyle=1
```

Plot the two sine waves with the random noise in the middle, thereby turning them into a single signal.

```
OPLOT, HILBERT(sandwich, -1)
```

Plot the sandwiched wave forms. Note that the sine waves are phase-shifted to the right by 90 degrees, while the noise data has not shifted at all, but rather has been distorted vertically (its amplitude) by the effect of the two adjacent phase-shifted sine waves. This is because the sine waves and the noise data were set up to be a single signal.

See Also

FFT, HANNING

HIST_EQUAL Function

Standard Library function that returns a histogram-equalized image or vector.

Usage

result = HIST_EQUAL(*image*)

Input Parameters

image – The image to be equalized.

Returned Value

result – An array that has been histogram equalized.

Input Keywords

Binsize – The size of the bin, i.e., the number of elements to consider as having a single value. If not specified, a value of 1 is used.

Minv – The minimum value to be used. Should be greater than 0. All input elements in *image* less than or equal to *min* will be output as 0. If not specified, 0 is used.

Maxv – The maximum value to be used. If not specified, the largest value of the elements in *image* is used. Input elements greater than *max* are output as 255.

Top – If specified, scales the result from 0 to *Top* before it is returned.

Discussion

In many images, most pixels reside in a few small subranges of the possible values. By spreading the distribution so that each range of pixel values contains an approximately equal number of members, the information content of the display is maximized.

To equalize the histogram of display values, the count-intensity histogram of the image is required. This is a vector in which the *i*th element contains the number of pixels with an intensity equal to the minimum pixel value of the image plus *i*. The vector is of long integer type and has one more element than the difference between the maximum and minimum values in the *image*. (This assumes a *Binsize* of 1 and an *image* that is not of byte type.) The sum of all the elements in the vector is equal to the number of pixels in the image.

HIST_EQUAL uses the HISTOGRAM function to obtain the density distribution of the image. This distribution is integrated to obtain the cumulative density probability function. Finally, the distribution is normalized so that its maximum element has a value of 255.

If *image* is of floating-point data type, its range of values should be at least 255, unless the *Binsize* keyword is used. If *image* is of byte data type, any *Binsize* keyword is ignored.

Sample Usage

Histogram equalization is commonly used in medical photography and X-rays. It causes the image gray levels that have the most pixels to be allocated the most display levels, thereby maximizing the transfer of information from an image.

Unfortunately, it is this very effect that can sometimes cause unsatisfactory results – histogram equalization chooses a display mapping based on the area covered by the various features in the image, rather than their importance. This can cause the contrast enhancement of reconstruction artifacts in the large background area, while small features of medical interest are sacrificed.

Example

This example uses the HIST_EQUAL function to manipulate the whirlpool image found in the PV-WAVE `wave/data` directory. The commands shown in this example produce the image on the right below:

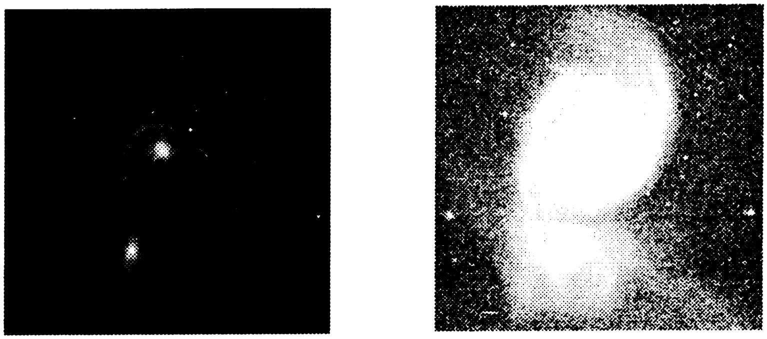


Figure 2-16 The HIST_EQUAL function has been used to make the visual elements of this 512-by-512 galaxy image more pronounced.

```
whirlpool = BYTARR(512,512)
GET_LUN, unit
filename = 'whirlpool.img'
OPENR, unit, filename
READU, unit, whirlpool
CLOSE, unit
FREE_LUN, unit
```

Create a 512-by-512 byte array, get the next free logical unit number (LUN), open the file, read the image into the array, and free the LUN.

```
!Order = 1
```

Transfer the image from top to bottom.

```
WINDOW, 2, XSize=500, YSize=500
TVSCL, whirlpool
```

Open the window and display the image.

```
WINDOW, 0, XSize=500, YSize=500
image = HIST_EQUAL(whirlpool)
TVSCL, HIST_EQUAL(image)
```

Open another window and display the histogram-equalized image.

See Also

HISTOGRAM, HIST_EQUAL_CT

For more information, see *Histogram Equalization* on page 155 of the *PV-WAVE User's Guide.*

HIST_EQUAL_CT Procedure

Standard Library procedure that uses an input image parameter, or the region of the display you mark, to obtain a pixel distribution histogram. The cumulative integral is taken and scaled, and the result is applied to the current color table.

Usage

HIST_EQUAL_CT [, *image*]

Input Parameters

image — The image whose histogram is to be used in determining the new color tables:

- If *image* is supplied, it is assumed to be the image that was last loaded to the display.
- If *image* is omitted, you are prompted to mark the diagonal corners of a region of the display with the mouse. The *image* must be a byte image, scaled the same way as the image loaded to the display.

Keywords

None.

Example

This is an example of how to obtain a pixel distribution histogram of a displayed image. (It uses the aerial view of Boulder, Colorado contained in the PV-WAVE `wave/data` directory.)

The result is applied to the current color table using the *image* parameter. Note that this example will only work if the original image contains values in the range of 0 to 255.

```
aerial_view = BYTARR(512,512)
GET_LUN, unit
OPENR, unit, 'aerial_demo.img'
```

Create a 512-by-512 byte array, get the next free logical unit number (LUN), and open the file.

```
READU, unit, aerial_view
CLOSE, unit
FREE_LUN, unit
```

Read the data into the array aerial_view, close the file, and free the LUN.

```
WINDOW, 1, XSize=512, YSize=512, $
   title='Aerial View of Boulder, CO'
TV, aerial_view
```

Open the window and display the image.

```
HIST_EQUAL_CT, aerial_view
```

Load the color table with a histogram-equalized distribution.

See Also

HIST_EQUAL, HISTOGRAM

For more information, see *Histogram Equalization* on page 155 of the *PV-WAVE User's Guide.*

HISTOGRAM Function

Returns the density function of an array.

Usage

result = HISTOGRAM(*array*)

Input Parameters

array — The vector or array for which the density function will be computed.

Returned Value

result — A longword vector equal to the density function of the input *array*.

Input Keywords

Binsize — The size of the bin (i.e., the range of values to consider as having a single value). If not specified, a value of 1 is used.

Max — The maximum value to consider. If not specified, *array* is searched for its largest value.

Min — The minimum value to consider. If not specified and *array* is a byte data type, 0 is used. If not specified and *array* is one of the other data types, *array* is searched for its smallest value.

Discussion

In the simplest case (in which *array* ranges in value from 0 to some maximum value), the value of the density function at subscript *i* is equal to the number of array elements with a value of *i*.

For example, let F_i equal the value of element i, for i in the range $\{0 \ldots n-1\}$. Then H_v (the result of the HISTOGRAM function) is given by:

$$H_v = \sum_{i=0}^{n-1} P(F_i, v)$$

where

$$v = 0, 1, 2, \ldots, \left\lceil \frac{Max - Min}{Binsize} \right\rceil$$

and $P(F_i, v) = 1$ when

$$v \le (F_i - Min) / (Binsize < v + 1)$$

and $P(F_i, v) = 0$ otherwise.

Caution There may not always be enough virtual memory available to create density functions of arrays that contain a large number of bins. For information on virtual memory and PV-WAVE, see Chapter 11, *Tips for Efficient Programming*, in the *PV-WAVE Programmer's Guide.*

Sample Usage

Histograms are useful in a variety of applications, and can often provide signs as to what type of image processing should be performed. For example, photos sent back via satellite from outer space are usually accompanied by histograms. If the histogram for a photo contains a large spike, and the rest of the histogram is generally flat, this typically indicates that a histogram equalizing operation (such as the HIST_EQUAL function) is needed. Such an operation would spread out the pixels more evenly, thereby improving contrast and bringing out greater detail in the image.

Histograms can also be used to provide clues about images. For example, running a histogram on a series of identical photos taken at different times of the day may show the histogram peak shifting to the right – an indication that the average brightness is higher in that photo, and therefore more likely to be have been taken at a sunnier part of the day.

Similarly, you can use histograms to compare two images of the same scene more fairly. By shifting the histogram of one scene so that it is aligned with that of the other scene, you can equalize the level of brightness in both images.

Example 1

The data for this example is from Hinkley (1977) and Velleman and Houglin (1981). Data includes measurements (in inches) of precipitation in Minneapolis/St. Paul during the month of March for 30 consecutive years.

```
x = [0.77, 1.74, 0.81, 1.20, 1.95, 1.20, $
   0.47, 1.43, 3.37, 2.20, 3.00, 3.09, 1.51,$
   2.10, 0.52, 1.62, 1.31, 0.32, 0.59, 0.81, $
   2.81, 1.87, 1.18, 1.35, 4.75, 2.48, 0.96, $
   1.89, 0.90, 2.05]

table = HISTOGRAM(x, Binsize = 0.444)
```

Call HISTOGRAM.

```
PRINT, '   Bin Number    Count' &$
PRINT, '   ----------    -----' &$
FOR i = 1, 10 DO PRINT, i, table(i-1)

Bin Number    Count
----------    -----
     1          4
     2          8
     3          5
     4          5
     5          3
     6          1
     7          3
```

```
        8            0
        9            0
       10            1
```

Example 2

This example exhibits how histogram equalization of an image better distributes pixel values. An image of a galaxy is read and displayed, then the density function of that image is plotted. After the image is histogram equalized, it is displayed, along with a plot of the density function of the equalized image.

```
OPENR, unit, FILEPATH('whirlpool.img', $
   Subdir = 'data'), /Get_Lun
```

Open the file containing the galaxy image.

```
g = BYTARR(512, 512)
```

Create an array large enough to hold the image.

```
READU, unit, g
```

Read the image.

```
FREE_LUN, unit
```

Close the file and free the file unit number.

```
!Order = 1
```

```
WINDOW, 0, Xsize = 512, Ysize = 512
```

Create a window with the same dimensions as the image.

```
TV, g
```

Display the original image.

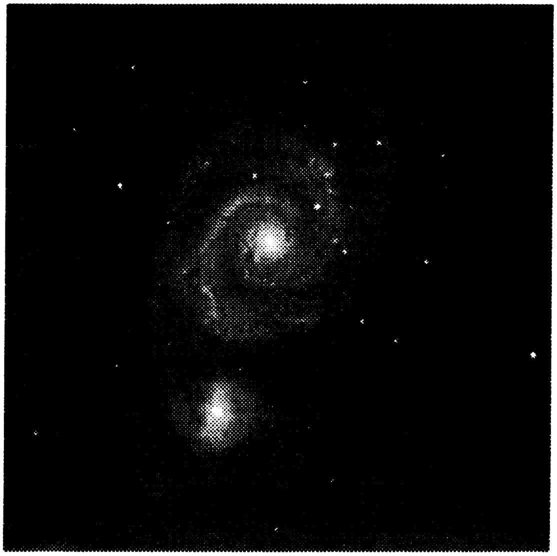


Figure 2-17 Original galaxy image.

```
hist_g = HISTOGRAM(g)
```

Compute the density function of the image.

```
WINDOW, 1, Xsize = 512, Ysize = 512
```

Create a window to display a plot of the result of the density function of the image.

```
PLOT, hist_g, Xrange = [20, 100], $
   Yrange = [0, 30000], Title = $
   'Density Function of Original Image'
```

Plot the result of the density function of the image.

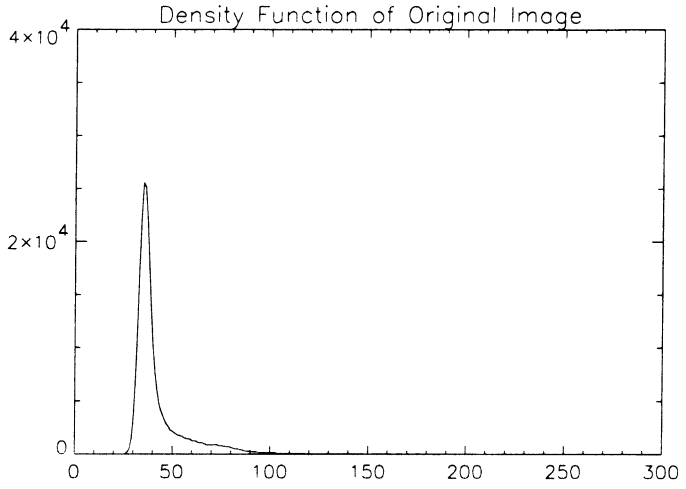


Figure 2-18 Plot of density function of original galaxy image.

```
g2 = HIST_EQUAL(g)
```

Histogram equalize the galaxy image.

```
WINDOW, 2, Xsize = 512, Ysize = 512
```

Create a window with the same dimensions as the histogram equalized image.

```
TV, g2
```

Display the equalized image.

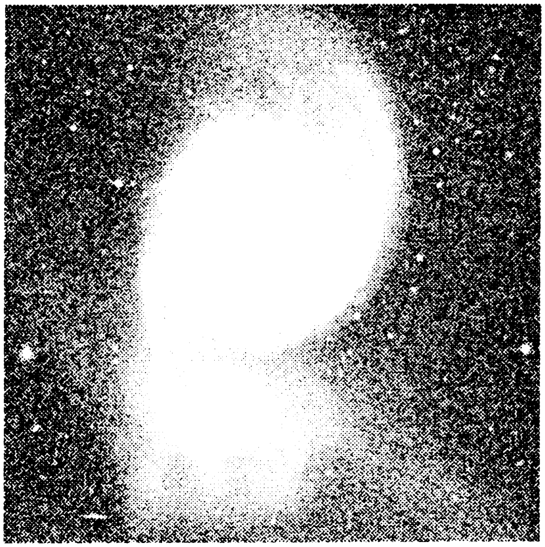


Figure 2-19 Histogram equalized galaxy image.

```
hist_g2 = HISTOGRAM(g2)
```

Compute the density function of the equalized image.

```
WINDOW, 3, Xsize = 512, Ysize = 512
```

Create a window to display a plot of the result of the density function of the equalized image.

```
PLOT, hist_g2, Xrange = [20, 100], $
   Yrange = [0, 30000], Title = $
   'Density Function of Equalized Image'
```

Plot the result of the density function of the equalized image.

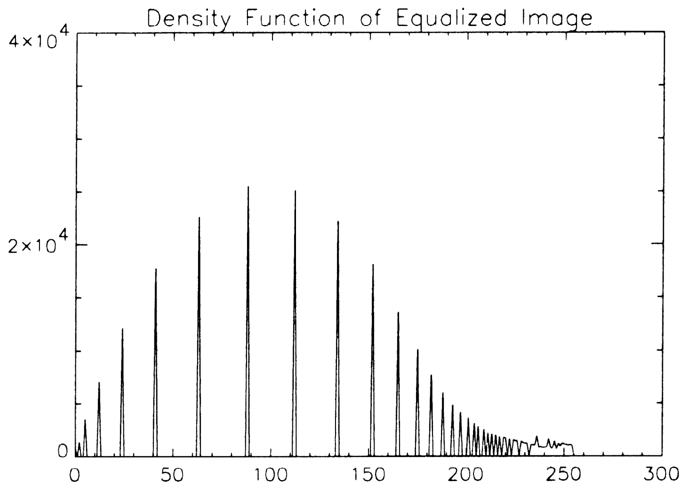


Figure 2-20 Plot of density function of equalized galaxy image.

See Also

HIST_EQUAL, HIST_EQUAL_CT

HLS Procedure

Standard Library procedure that generates and loads color tables into an image display device based on the HLS color system. The resulting color table is loaded into the display system.

Usage

HLS, *ltlo, lthi, stlo, sthi, hue, lp* [, *rgb*]

Input Parameters

ltlo – The starting color lightness or intensity, expressed as 0 to 100 percent. Full lightness (the brightest color) is 100 percent.

lthi – The ending color lightness or intensity, expressed as 0 to 100 percent.

stlo – The starting color saturation, expressed as 0 to 100 percent. Full saturation (undiluted or pure color) is expressed as 100 percent.

sthi – The ending color saturation, expressed as 0 to 100 percent.

hue – The starting hue, expressed as 0 to 360 degrees.

lp – The number of loops around the color cone. The value may be floating-point. A positive value will traverse the color cone in a clockwise direction; a negative value will traverse the color cone in a counterclockwise direction.

Output Parameters

rgb – An optional 256-by-3 integer output array containing the red, green, and blue vector values that were translated from the HSV system and loaded into the color tables. The following example shows the ordering of the RGB values in the output array:

```
Red_Vec(i) = RGB(i, 0)
Green_Vec(i) = RGB(i, 1)
Blue_Vec(i) = RGB(i, 2)
```

Keywords

None.

Discussion

The HLS procedure traces a spiral through the HLS color cone. Points along the spiral are converted from HLS values to RGB values and then loaded into the color tables with the TVLCT procedure. The color representation of pixel values between 0 and 255 is linearly interpolated from the hue, saturation, and lightness of the end points.

Example

The statement:

```
HLS, 0, 100, 50, 100, 0, -2.5
```

loads a color table that ranges from 0 to 100 percent in lightness or intensity and from 50 to 100 percent in saturation. This color table begins with a color of red, and makes two and a half full loops around the color solid in the direction of red to blue.

See Also

HSV, HLS, COLOR_CONVERT, COLOR_EDIT, LOADCT, MODIFYCT, RGB_TO_HSV, TVLCT, WgCeditTool, WgCtTool

For more information, see *The HSV and HLS Color Systems* on page 308 of the *PV-WAVE User's Guide.*

The HLS procedure is adapted from a program in *Fundamentals of Interactive Computer Graphics* by Foley and Van Dam, Addison Wesley Publishing Company, Reading, MA, 1982.

HSV Procedure

Standard Library procedure that generates and loads color tables into an image display device based on the HSV color system. The final color table is loaded into the display device.

Usage

HSV, *vlo, vhi, stlo, sthi, hue, lp* [, *rgb*]

Input Parameters

vlo – The starting color value or intensity, expressed as 0 to 100 percent. Full intensity is 100 percent.

vhi – The ending color value or intensity, expressed as 0 to 100 percent.

stlo – The starting color saturation, expressed as 0 to 100 percent. Full saturation (undiluted or pure color) is expressed as 100 percent.

sthi – The ending color saturation, expressed as 0 to 100 percent.

hue – The starting hue, expressed as 0 to 360 degrees.

lp – The number of loops around the color cone. The value may be floating-point. A positive value will traverse the color cone in a clockwise direction; a negative value will traverse the color cone in a counterclockwise direction.

Output Parameters

rgb – An optional 256-by-3 integer output array containing the red, green, and blue vector values that were translated from the HSV system and loaded into the color tables. The following example shows the ordering of the RGB values in the output array:

```
Red_Vec(i) = RGB(i, 0)
Green_Vec(i) = RGB(i, 1)
Blue_Vec(i) = RGB(i, 2)
```

Keywords

None.

Discussion

The HSV procedure traces a spiral through the HSV color cone. Points along the spiral are converted from HSV values to RGB values and then loaded into the color tables with the TVLCT procedure. The color representation of pixel values between 0 and 255 is linearly interpolated from the hue, saturation, and value of the end points.

Example

The statement:

```
HSV, 0, 100, 50, 100, 0, -2.5
```

loads a color table that ranges from 0 to 100 percent in intensity or brightness and from 50 to 100 percent in saturation. This color table begins with a color of red, and makes two and a half full loops around the color solid in the direction of red to blue.

See Also

HSV, HLS, COLOR_CONVERT, COLOR_EDIT, LOADCT, MODIFYCT, RGB_TO_HSV, TVLCT, WgCeditTool, WgCtTool

For more information, see *The HSV and HLS Color Systems* on page 308 of the *PV‑WAVE User's Guide.*

The HSV procedure is adapted from a program in *Fundamentals of Interactive Computer Graphics* by Foley and Van Dam, Addison Wesley Publishing Company, Reading, MA, 1982.

HSV_TO_RGB Procedure

Standard Library procedure that converts colors from the HSV color system to the RGB color system.

Usage

HSV_TO_RGB, *h, s, v, red, green, blue*

Input Parameters

h – The hue variable. May be either vector or scalar, in the range of 0 to 360.

s – The saturation variable. Must be the same dimension as *h*, in the range of 0 to 1.

v – The value variable. Must be the same dimension as *h*, in the range 0 to 1.

Output Parameters

red – Red color output value(s). Will be short integer(s), the same dimension as *h*, and in the range of 0 to 255.

green – Green color output value(s). Will be short integer(s), the same dimension as *h*, and in the range of 0 to 255.

blue – Blue color output value(s). Will be short integer(s), the same dimension as *h*, and in the range of 0 to 255.

Keywords

None.

Discussion

HSV_TO_RGB provides a convenient way to convert from the HSV (hue, saturation, value) color system to the RGB (red, green, blue) color system. Most output devices capable of displaying color use the RGB color system.

Example

The statement:

```
HSV_TO_RGB, 0, 1, 1, red, green, blue
```

returns `red=255`, `green=0`, `blue=0`. You can use the red, green, and blue values to set color table values with the TVLCT procedure.

See Also

HSV, HLS, COLOR_CONVERT, COLOR_EDIT, LOADCT, MODIFYCT, RGB_TO_HSV, TVLCT, WgCeditTool, WgCtTool

For more information, see *The HSV and HLS Color Systems* on page 308 of the *PV-WAVE User's Guide.*

IMAGE_CONT Procedure

Standard Library procedure that overlays a contour plot onto an image display of the same array.

Usage

IMAGE_CONT, *array*

Input Parameters

array – The two-dimensional array to display.

Input Keywords

Aspect – Set to 1 to change the image's aspect ratio. It assumes square pixels. If *Aspect* is not set, the aspect ratio is retained.

Interp – Set to 1 to interpolate the image with the bilinear method, when and if the image is resampled. Otherwise, the nearest neighbor method is used.

Window_Scale – Set to 1 to scale the window size to the image size. Otherwise, the image size is scaled to the window size. *Window_Scale* is ignored when outputting to devices with scalable pixels (e.g., PostScript devices).

Discussion

If the device you are using has scalable pixels, then the image is written over the plot window.

Example

This example uses IMAGE_CONT to display the image and overlaid contour plot depicting different elevations of the surface defined by

$$f(x, y) = x\sin(y) + y\cos(x) - 10\sin(xy/4)$$

where

$$(x, y) \in \{\mathbb{R}^2 | x, y \in [-10,10]\}$$

```
.RUN
```

```
- FUNCTION f, x, y
- RETURN, x * SIN(y) + y * COS(x) - 10 * $
- SIN(0.25 * x * y)
- END
```

Define the function.

```
x = FINDGEN(101)/5 - 10
```

Create vector of x-coordinates.

```
y = x
```

Create vector of y-coordinates.

```
z = FLTARR(101, 101)
```

Create an array to hold the function values.

```
FOR i = 0, 100 DO FOR j = 0, 100 DO $
   z(i, j) = f(x(i), y(j))
```

Evaluate the function at the given x- and y-coordinates and place the result in Z.

```
IMAGE_CONT, z
```

Display image and contour plot.

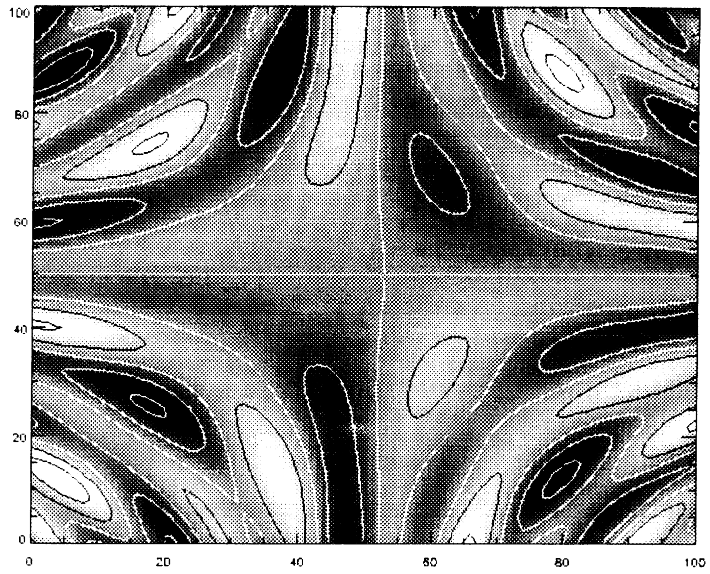


Figure 2-21 Image and contour plot of $f(x,y) = x\sin(y) + y\cos(x) - 10\sin(xy/4)$.

See Also

CONTOUR, SHOW3, TV, TVSCL

For details on methods of interpolation, see *Efficiency and Accuracy of Interpolation* on page 170 of the *PV-WAVE Programmer's Guide.*

IMAGINARY Function

Returns the imaginary part of a complex number.

Usage

result = IMAGINARY(*complex_expr*)

Input Parameters

complex_expr – A complex number (one with both a real and imaginary part). Can be of any dimension.

Returned Value

result – The imaginary part as a single-precision floating-point value. It is of the same dimension as *complex_expr*.

Keywords

None.

Discussion

IMAGINARY can be used for a variety of applications – one example is using it to find the phase angle of a complex result, such as a filter, by dividing the arctangent of the imaginary part by the real part.

Example

```
x = COMPLEX(0, 2)
PRINT, IMAGINARY(x)
   2.00000
```

See Also

CINDGEN, COMPLEX

IMG_TRUE8 Procedure

Generates a pseudo true-color image suitable for display on devices capable of displaying 256 simultaneous colors.

Usage

IMG_TRUE8, *red_img, grn_img, blu_img, rgb_img, red, grn, blu*

Input Parameters

red_img — A 2D image representing the red component of a true color image. *red_img* must be the same size as *grn_img* and *blu_img*.

grn_img — A 2D image representing the green component of a true color image.

blu_img — A 2D image representing the blue component of a true color image.

Output Parameters

rgb_img — A pseudo true color 8-bit image that can be displayed using the TV procedure (see Discussion below).

red — The red component of the color table.

grn — The green component.

blu — The blue component.

Keywords

None.

Discussion

The image generated by IMG_TRUE8 is suitable for display on devices with 8-bit planes of color. It is useful when you have

Landsat type images that you want to merge into a true color system.

Note For correct appearance, *rgb_img* should be displayed in a PV-WAVE window with 256 colors allocated to it. For example:

```
WINDOW, 0, Colors=256
```

Also, the proper color table needs to be loaded by using the command:

```
TVLCT, red, grn, blu, 0
```

where `red`, `grn`, and `blu` are the values obtained from IMG_TRUE8.

Then use the TV procedure to display the image:

```
TV, rgb_img
```

Tip On some systems it may be necessary to click in the image window to see the proper colors.

Examples

```
PRO img_demo1
```

This program displays a pseudo true-color Landsat image on an 8-bit color system.

```
winx = 477
winy = 512
```

Specify the window size.

```
red_img = BYTARR(winx, winy)
grn_img = BYTARR(winx, winy)
blu_img = BYTARR(winx, winy)
```

Set up the color components for the true color image.

```
OPENR, 1, !Data_Dir + 'boulder_red.img'
READU, 1, red_img
CLOSE, 1

OPENR, 1, !Data_Dir + 'boulder_grn.img'
READU, 1, grn_img
CLOSE, 1
```

```
OPENR, 1, !Data_Dir + 'boulder_blu.img'
READU, 1, blu_img
CLOSE, 1
```

Read in the data.

```
WINDOW, 0, Colors=256, XSize=winx, YSize=winy
```

Set up the display window.

```
IMG_TRUE8, red_img, grn_img, blu_img, $
   rgb_img,red, grn, blu
TVLCT, red, grn, blu, 0
TV, rgb_img
```

Create and display the true color image.

```
END
```

To see an example using the same data, except displayed in true 24-bit color on a 24-bit X workstation, see *Displaying Images on Monochrome Devices* on page 148 of the *PV-WAVE User's Guide*.

See Also

LOADCT

For a comparison of pseudo- and true-color images, see *Not all Color Images are True-color Images* on page 146 of the *PV-WAVE User's Guide.*

INDGEN Function

Returns an integer array with the specified dimensions.

Usage

result = INDGEN(dim_1, ... , dim_n)

Input Parameters

***dim**$_i$* – The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result – An initialized integer array. If the resulting array is treated as a one-dimensional array, then its initialization is given by the following:

$$array\ (i) = i, \text{ for } i = 0, 1, \ldots, \left(\prod_{j=1}^{n} D_j - 1\right)$$

Keywords

None.

Example

This example creates a 4-by-2 integer array.

```
a = INDGEN(4, 2)
```
Create integer array.

```
INFO, a
VARIABLE      INT        = Array(4, 2)
```

```
PRINT, a
0     1     2     3
   4     5     6     7
```

See Also

BINDGEN, CINDGEN, DINDGEN, FINDGEN, LINDGEN, SINDGEN

INFO Procedure

Displays information on many aspects of the current PV-WAVE session.

Usage

INFO, $expr_1$, ... , $expr_n$

Input Parameters

***expr**$_i$* – The expressions specifying the type of information to be displayed. These expressions are interpreted differently, depending on the keyword selected. If no keyword is selected, INFO displays basic information for its parameters.

Output Keywords

Breakpoints – Displays the breakpoint table containing the program module and location of each breakpoint.

Calls – Stores the procedure call stack, in the form of a string array, in a specified variable.

Each string element contains the name of the program module, source file name, and line number. Array element zero contains the information about the caller of INFO, element one contains information about its caller, and so on.

Calls is useful for programs that require traceback information.

Device – If present and nonzero, displays information about the currently selected graphics device.

Files – Displays information about file units:

- If input parameters are supplied, the value for *Files* is taken to be integer file-unit numbers, and information on the specified units is displayed.
- If no input parameters are supplied, information about all open file units is displayed.

Keys – Displays current function key definitions as set using the DEFINE_KEY procedure:

- If input parameters are supplied, *Keys* must be scalar strings containing the names of function keys, and information on the specified keys is displayed.
- If no input parameters are supplied, information on all function keys is displayed.

Memory – Reports the amount of dynamic memory currently in use by the PV-WAVE session, and the number of times dynamic memory has been allocated and deallocated.

Recall_Commands – Displays the currently saved commands. Input parameters are ignored.

Routines – Displays a list of all compiled procedures and functions with their parameter names. Keywords accepted by each module are enclosed in quotation marks.

Structures – Displays information on the structure of variables:

- If input parameters are supplied, the structure of those expressions is displayed.
- If no input parameters are supplied, all currently defined structures are shown.

Sysstruct – Displays information on all system structures (structures that begin with '!'). This keyword is a subset of the *Structures* keyword.

System_Variables – Displays information on all system variables. Input parameters are ignored.

Traceback — Displays the current nesting of procedures and functions. Input parameters are ignored.

Userstruct — Displays information on the regular user-defined structures (structures that do not begin with '!'). This keyword is a subset of the *Structures* keyword.

Discussion

You select information on a specific area by specifying the appropriate keyword from the above list. Only one keyword may be specified at a time.

If no input parameters or keywords are specified, INFO shows the current nesting of procedures and functions, all current variables at the current program level, and open files.

See Also

DEFINE_KEY, DOC_LIBRARY

For more information and examples, see Chapter 14, *Getting Session Information*, in the *PV-WAVE Programmer's Guide.*

INTARR Function

Returns an integer vector or array.

Usage

result = INTARR(dim_1, ... , dim_n)

Input Parameters

dim_i – The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result – An integer vector or array with the dimensions specified by dim_i.

Input Keywords

Nozero – Normally, INTARR sets every element of the result to zero. If *Nozero* is nonzero, this zeroing is not performed, thereby causing INTARR to execute faster.

Example

```
result = INTARR(2, 3)
PRINT, result
   0   0
   0   0
   0   0
```

See Also

BYTARR, FLTARR, INDGEN, LONARR

INTERPOL Function

Standard Library function that performs a linear interpolation of a vector using either a regular or irregular grid.

Usage

result = INTERPOL(*v*, *n*)

This form is used with a regular grid.

result = INTERPOL(*v*, *x*, *u*)

This form is used with an irregular grid.

Input Parameters

v — The dependent values of the vector that is to be interpolated. Must be one-dimensional. Can be of any data type except string.

n — The number of interpolated points.

x — The independent values of the vector that is to be interpolated. Must have the same number of values as *v*, and must be monotonic, either increasing or decreasing.

u — The independent values at which interpolation is to occur. Is not necessarily monotonic.

Returned Value

result — For a regular grid, a vector containing *n* points interpolated from vector *v*. For an irregular grid, a vector containing the same number of values as *u*.

Keywords

None.

Discussion

The result returned by INTERPOL differs depending on whether a regular or an irregular grid was used, as described below.

- **Regularly-gridded vectors**. The vector resulting from INTERPOL used with a regular grid is calculated in the following way, using the FIX function:

  $$result(i) = v(j) + (j - FIX(j))\ (v(j + 1) - v(j))$$

  where

  $j = i(m-1)/(n-1)$

  i is in the range $0 \leq i \leq (n-1)$

  m is the number of points in the input vector v.

  The output grid horizontal coordinates (abscissae values) are calculated in the following way, using the FLOAT function:

  $$abscissa\_value(i) = FLOAT(i)\ /\ m$$

  where i is in the range $0 \leq i < (n - 1)$.

- **Irregularly-gridded vectors**. The vector resulting from INTERPOL used with an irregular grid has the same number of elements as j and is calculated in the following way, using the FIX function:

  $$result(i) = v(j) + (j - FIX(j))\ (v(j + 1) - v(j))$$

  where $j = u(i)$.

Example

INTERPOL can be used in signal processing to reconstruct the signal between original samples of data. For example, suppose you have 5 sample data readings, [0, 5, 10, 5, 0], but you need 15 samples.

To get these additional samples, enter the following command:

```
out_vector = INTERPOL(in_vector, 15)
```

where `in_vector` has a value of [0, 5, 10, 5, 0] and `out_vector` yields the following values:

```
[0, 1.42857, 2.85714, 4.28571, 5.71429,
   7.14286, 8.57143, 10.0000, 8.57143,
   7.14286, 5.71429, 4.28571, 2.85714,
   1.42857, 0]
```

The data still starts and ends with zero, and the maximum is still ten, but all the points in between have been recalculated.

See Also

BILINEAR, SPLINE

INVERT Function

Returns an inverted copy of a square array.

Usage

result = INVERT(*array* [, *status*])

Input Parameters

array — A two-dimensional square array. May be of any data type except string.

Output Parameters

status — The name of a scalar variable used to accumulate errors from singular or near-singular arrays. Possible values are:

0	Successful completion.
1	A singular array, indicating that the inversion is invalid.
2	A warning that a small pivot element was used and it is likely that significant accuracy was lost.

Returned Value

result — An inverted copy of *array*.

Keywords

None.

Discussion

An input array of double-precision floating-point data type returns a result of identical type. An input array of any other type yields a result of single-precision floating-point data type.

Errors are accumulated in the optional *status* parameter, or the math error status indicator. This latter status may be checked using the CHECK_MATH function.

Caution Unless double-precision floating-point values are used for *array*, round off and truncation errors may occur, resulting in imprecise inversion.

INVERT uses the Gaussian elimination method (whose objective is the transformation of the given system into an equivalent system with upper-triangular coefficient matrix).

See Also

CHECK_MATH, DETERM, LUBKSB, LUDCMP, TRANSPOSE

ISHFT Function

Performs the bit shift operation on bytes, integers, and longwords.

Usage

result = ISHFT(p_1, p_2)

Input Parameters

p_1 — The scalar or array to be shifted.

p_2 — The scalar containing the number of bit positions and direction of the shift.

Returned Value

result — The shifted scalar or array value.

Keywords

None.

Discussion

If p_2 is positive, p_1 is left-shifted p_2 bit positions, with 0 bits filling vacated positions. If p_2 is negative, p_1 is right-shifted, again with 0 bits filling vacated positions.

Example

In this example, ISHFT is used to multiply and divide each element of a five-element vector by powers of 2.

```
a = BYTARR(5)
```

Create and initialize a five-element byte array.

```
FOR i = 0, 4 DO a(i) = 4 * i
PRINT, a
0   4   8   12   16
```

```
PRINT, a, ISHFT(a, -2)
```
Divide each element of A by 4.

```
0    4    8    12    16
0    1    2    3     4
```

```
PRINT, a, ISHFT(a, 1)
```
Multiply each element of A by 2.

```
0    4     8    12    16
0    8    16    24    32
```

See Also

SHIFT

JOURNAL Procedure

Provides a record of an interactive session by saving in a file all text entered from the terminal in response to a prompt.

Usage

JOURNAL [, *param*]

Input Parameters

param — A string parameter whose use depends on whether journaling is in progress when JOURNAL is called, and whether *param* is explicitly set:

- If journaling is not in progress and *param* is supplied, *param* sets the name of the journal file into which the session's commands will be written.
- If journaling is not in progress and *param* is not supplied, the default journal file named `wavesave.pro` is used.
- If journaling is in progress and *param* is supplied, the contents of the *param* string is written directly into the currently open journal file.

- If journaling is in progress and *param* is not supplied, the current journal file is closed and the logging process is terminated.

Keywords

None.

Discussion

The first call to JOURNAL starts the logging process. The read-only system variable !Journal is set to the file unit into which all session commands are written. Once the logging is initiated, a call to JOURNAL with no parameters closes the log file and terminates the logging process. If logging is in effect and a parameter is supplied, the parameter is simply written to the journal file.

See Also

RESTORE, SAVE

JUL_TO_DT Function

Converts a Julian day number to a PV-WAVE Date/Time variable.

Usage

result =JUL_TO_DT(*julian_day*)

Input Parameters

julian_day – A Julian day number or array of Julian day numbers.

Returned Value

result – A PV-WAVE Date/Time variable containing the converted data.

Keywords

None.

Discussion

The Julian day number is based on the date September 14, 1752.

Example

```
dt = JUL_TO_DT(87507)
```

Converts the Julian day 87507 into a PV-WAVE Date/Time variable.

```
print, dt
   { 1992 4 15 0 0 0.00000 87507.000 0}
```

See Also

VAR_TO_DT, STR_TO_DT, SEC_TO_DT

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV-WAVE User's Guide.*

KEYWORD_SET Function

Tests if an input expression has a nonzero value.

Usage

result = KEYWORD_SET(*expr*)

Input Parameters

expr — The expression to be tested. Usually a named variable.

Returned Value

result — A nonzero value, if *expr* is defined and nonzero.

Keywords

None.

Discussion

KEYWORD_SET is especially useful in user-written procedures and functions when you want to process keywords that can be interpreted as being either true (keyword is present and nonzero) or false (keyword was not used, or was set to zero).

It can also be used to test whether an expression evaluates to zero, or whether a variable has been set.

Example 1

Assume you type the following in PV-WAVE:

```
IF KEYWORD_SET(x) THEN PRINT, $
   'It is set' ELSE PRINT, 'Not set'
```

You will see:

```
Not set
```

You will see:

```
Not set
```

because the value of x has not been initialized. On the other hand, if you set x to a specific value, say 2, you would see:

```
WAVE> x = 2
WAVE> IF KEYWORD_SET(x) THEN PRINT, $
   'It is set' ELSE PRINT, 'Not set'
   It is set
```

Example 2

The following user-defined routine uses KEYWORD_SET to make a call to print the results of a squaring operation:

```
FUNCTION SQUARE_IT, Value, Print_Flag = Print
   Squared_Val = Value * Value
   IF (KEYWORD_SET(Print)) THEN PRINT,$
      Squared_Val
   RETURN, Squared_Val
END
```

To run this routine:

```
WAVE> .run SQUARE_IT.PRO
WAVE> y = SQUARE_IT(5)
WAVE> PRINT, y
      25
WAVE> y = SQUARE_IT(10, /Print_Flag)
      100
```

See Also

N_ELEMENTS, N_PARAMS

LEEFILT Function

Standard Library function that performs image smoothing by applying the Lee Filter algorithm.

Usage

result = LEEFILT(*image* [, *n*, *sigma*])

Input Parameters

image — The array to be smoothed. Can be a one- or two-dimensional array.

n — The value of 2*n* + 1 is used for the side of the filter box. The side of the filter box must be smaller than the smallest dimension of *image*. The default value for *n* is 5.

sigma — The estimate of the standard deviation. The default value is 5. Must be a positive value.

Note If *sigma* is negative, you will be prompted for a value to be typed in, the value will be displayed, and the filtered image will be displayed with the TVSCL command. This cycle will continue until a zero value of *sigma* is entered.

Returned Value

result — A two-dimensional array containing the smoothed image.

Keywords

None.

Discussion

LEEFILT performs image smoothing by applying the Lee Filter algorithm. This algorithm assumes that the sample mean and variance of a value is equal to the local mean and variance of all values within a fixed range surrounding it. LEEFILT smooths additive signal noise by generating statistics in a local neighborhood and comparing them to the expected values.

Since LEEFILT is not very computationally expensive, it can be used for near real-time image processing. It can be used on vectors as well as images.

See Also

MEDIAN, SMOOTH, TVSCL

For details on the Lee Filter, see the article by Jong-Sen Lee, "Digital Image Enhancement and Noise Filtering by Use of Local Statistics," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Volume PAMI-2, Number 2, pages 165-168, March 1980.

LEGEND Procedure

Standard Library procedure that lets you put a legend on a plot or graph.

Usage

LEGEND, *label* [, *col, lintyp, psym, data_x, data_y, delta_y*]

Input Parameters

label – A row of labels, one for each data line. May be characters or numbers.

col – An array containing the color to be used for each row of the legend. If *col* is omitted (or if there are fewer colors than labels), the system variable !P.Color is used.

lintyp – An array containing the values to be used in drawing each line of the legend. If *lintyp* is omitted (or if there are fewer line types than labels), the system variable !P.Linestyle is used.

psym – An array containing the value of the plot symbols to be used in the legend. The plot symbols correspond to the values of the system variable !P.Psym. If *psym* is omitted (or if there are fewer plot symbols than labels), the system variable !P.Psym is used.

data_x – The X coordinate of the upper-left corner of the legend in data coordinates. If *data_x* is omitted, you are prompted for a value.

data_y – The Y coordinate of the upper-left corner of the legend in data coordinates. If *data_y* is omitted, you are prompted for a value.

delta_y – The vertical spacing between the lines of the legend, expressed in data coordinates. If *delta_y* is omitted, you are prompted for a value.

Keywords

None.

Discussion

You have control of the color, line type, and plotting symbol for each row of the legend using the available keywords. The size of the text is controlled by the system variable !P.Charsize.

See Also

XYOUTS, PLOT

For more information, see Chapter 4, *System Variables.*

LINDGEN Function

Returns a longword integer array with the specified dimensions.

Usage

result = LINDGEN(*dim*$_1$, ... , *dim*$_n$)

Input Parameters

dim$_i$ — The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result — An initialized longword integer array. If the resulting array is treated as a one-dimensional array, then its initialization is given by the following:

$$array\,(i) = \mathrm{LONG}\,(i),\ \text{for}\ i = 0, 1, \ldots, \left(\prod_{i=1}^{n} D_j - 1\right)$$

Keywords

None.

Example

This example creates a 4-by-2 longword integer array.

```
a = LINDGEN(4, 2)
```

Create longword integer array.

```
INFO, a
VARIABLE     LONG         = Array(4, 2)

PRINT, a
0     1     2     3
4     5     6     7
```

See Also

BINDGEN, CINDGEN, DINDGEN, FINDGEN, INDGEN, SINDGEN, INTARR

LINKNLOAD Function

Provides simplified access to external routines in shareable images.

Usage

result = LINKNLOAD(*object*, *symbol* [, *param*$_1$, ..., *param*$_n$])

Input Parameters

object — A string specifying the filename, optionally including file path, of the sharable object file to be linked and loaded.

symbol — A string specifying the function name symbol entry point to be invoked in the shared object file.

Output Parameters

param$_i$ — The data to be passed as a parameter to the function. Any PV-WAVE data type except structure can be used.

Returned Value

result — A scalar whose default is assumed to be of type longword unless it is specified with one of the keywords described below.

Keywords

D_Value — Specifies that the returned scalar is of type double-precision floating point.

F_Value — Specifies that the returned scalar is of type single-precision floating point.

S_Value — Specifies that the returned scalar is of type string.

Discussion

LINKNLOAD provides a simple, yet powerful, mechanism for dynamically invoking your own code from PV-WAVE on the following operating systems that support dynamic linking: AIX 3.1, HPUX 8.0, SunOS 4.1, and VMS 5.0.

LINKNLOAD calls a function in an external sharable object and returns a scalar value. It is the simplest method for attaching your own C code to PV-WAVE.

Parameters are passed through PV-WAVE to the specified external function by reference, thus allowing the external function to alter values of PV-WAVE variables.

Caution Be careful to ensure that the number, type, and dimension of the parameters passed to the external function match what it expects (this can most easily be done from within PV-WAVE before calling LINKNLOAD). Furthermore, the length of string parameters must not be altered and multi-dimensional arrays are flattened to one-dimensional arrays.

Notes and Cautions

For AIX 3.1, the symbol entry point must be specified when the external shareable object is built, by using the `-e` flag, and thus the function symbol parameter to LINKNLOAD has no effect on AIX. In addition, for AIX, `wavevars` may not be called in a C function called from PV-WAVE via LINKNLOAD.

LINKNLOAD is not available for operating systems that do not support dynamic linking, such as DEC ULTRIX and SGI IRIX.

If you run PV-WAVE and call LINKNLOAD and then relink your C function (or C wrapper) and try to call LINKNLOAD again in the same session, PV-WAVE will crash. You must exit and then rerun PV-WAVE for the newly linked C routine to work.

LINKNLOAD only works directly for C. To call a FORTRAN routine, you must first write a simple C function that calls your FORTRAN code, then call the C function from PV-WAVE.

Variables that are shared between PV-WAVE and a C function must be created by PV-WAVE and their size can not be modified by the C function.

It is possible to pass a constant as a parameter to a C function from PV-WAVE via LINKNLOAD, but of course the C function can not pass a value back via that parameter.

Although `wavevars` returns pointers to the data associated with PV-WAVE's variables, it should be kept in mind that these addresses must be treated as being a snap-shot because the data pointer associated with a particular PV-WAVE variable may change after execution of certain PV-WAVE system commands.

Using LINKNLOAD, care must be taken to ensure that the number, type, and dimension of the parameters passed to the C function (or C wrapper) match what the C function (or C wrapper) expects (this can most easily be done from within PV-WAVE before calling LINKNLOAD). Furthermore, the length of string parameters must not be altered and multi-dimensional arrays are flattened to one-dimensional arrays.

Example

The following PV-WAVE code demonstrates how to invoke a C function using LINKNLOAD. For more information on compiling shareable objects, see *Using LINKNLOAD to Call External Programs* on page 319 of the *PV-WAVE Programmer's Guide*.

In this example, parameters are passed to the C external function using the conventional (*argc*, *argv*) UNIX strategy. *argc* indicates the number of data pointers which are passed from PV-WAVE within the array of pointers called *argv*. The pointers in *argv* can be cast to the desired type as the following program demonstrates.

You can find the following listed file in:

```
$WAVE_DIR/util/linknload/example.c
```

```
#include <stdio.h>
typedef struct complex {
   float r, i;
} complex;
long WaveParams(argc,argv)
   int argc;
   char *argv[];
{
   char *b;
   short *s;
   long *l;
   float *f;
   double *d;
   complex *c;
   char **str;
 if (argc != 7) {
     fprintf(stderr,"wrong # of parameters\n");
     return(0);

 }

 b = ((char **)argv)[0];
 s = ((short **)argv)[1];
 l = ((long **)argv)[2];
 f = ((float **)argv)[3];
 d = ((double **)argv)[4];
 c = ((complex **)argv)[5];
 str = ((char ***)argv)[6];
 fprintf(stderr,"%d %d %ld %g %g <%g%gi>
    '%s'\n", (int) b[0],(int)s[0],(long)l[0],
    f[0],d[0],c[0].r,c[0].i,str[0]);
  return(12345);
}
```

Accessing the External Function with LINKNLOAD

The following PV-WAVE code demonstrates how the C function defined in the previous discussion could be invoked.

```
ln = LINKNLOAD('example.so','WaveParams', $
   byte(1),2,long(3), float(4),double(5), $
   complex(6,7),'eight')
```

The resulting output is:

```
1 2 3 4 5 <6,7i> 'eight'
```

Using the INFO command, you can see that LINKNLOAD returns the scalar value 12345, as expected.

```
INFO, ln
   LN      LONG      =      12345
```

The example program works with both scalars and arrays since the actual C program above only looks at the first element in the array and since PV-WAVE collapses multi-dimensional arrays to one-dimensional arrays:

```
ln = LINKNLOAD('example.so','WaveParams', $
   [byte(1)],[[2,3],[4,5]], [long(3)], $
   [float(4)],[double(5)],[complex(6,7)], $
   ['eight'])
```

The resulting output is:

```
 1 2 3 4 5 <6,7i> 'eight'
```

See Also

SIZE

LN03 Procedure

Standard Library procedure that opens or closes an output file for LN03 graphics output. The file can then be printed on an LN03 printer.

Usage

LN03 [, *filename*]

Input Parameters

filename – The name of the file that will contain the LN03 graphics output.

Keywords

None.

Discussion

You may also use the DEC SIXEL device driver for LN03 graphics ouput (the LN03 procedure was created before this driver was available). For details, see the section *SIXEL Output* on page A-58 in Appendix A, *Output Devices and Window Systems*, in the *PV-WAVE User's Guide.*

Example

To open a file for LN03 output, enter the following command:

```
LN03, 'myfile'
```

where `myfile` is the name of the file that will be sent to the LN03 printer.

To close the output file, call the procedure without a parameter.

LOADCT Procedure

Standard Library procedure that loads a predefined PV-WAVE color table.

Usage

LOADCT [, *table_number*]

Input Parameters

table_number — A number between 0 and 15; each number is associated with a predefined color table.

Input Keywords

Silent — If present and nonzero, suppresses the message indicating that the color table is being loaded.

Discussion

Predefined color tables are distributed with PV-WAVE in the file `colors.tbl`. There are 16 predefined color tables, with indices ranging from 0 to 15, as shown in Table 2-9.

To see a menu listing of these color tables, call LOADCT with no parameters.

Table 2-9: Standard PV-WAVE Color Tables

Number	Name
0	Black and White Linear
1	Blue/White
2	Green/Red/Blue/White
3	Red Temperature
4	Blue/Green/Red/Yellow
5	Standard Gamma-II
6	Prism
7	Red/Purple
8	Green/White Linear
9	Green/White Exponential
10	Green/Pink
11	Blue/Red
12	16 Level
13	16 Level II
14	Steps
15	PV-WAVE Special

Examples

```
LOADCT, 3
```

Loads the Red Temperature color table.

```
LOADCT, 11, /Silent
```

Loads the Blue/Red color table without displaying a message.

See Also

TVLCT, COLOR_EDIT, MODIFYCT, STRETCH, TEK_COLOR, WgCtTool

For more information, including a comparison of LOADCT and TVLCT, see *Experimenting with Different Color Tables* on page 310 of the *PV-WAVE User's Guide*.

LOAD_HOLIDAYS Procedure

Makes the value of the !Holiday_List system variable available to the Date/Time routines.

Usage

LOAD_HOLIDAYS

Parameters

None.

Keywords

None.

Discussion

Run LOAD_HOLIDAYS after you:

- Restore a PV-WAVE session in which you used the CREATE_HOLIDAYS function. Running this procedure makes the restored !Holiday_List system variable available to the Date/Time routines.
- Directly change the value of the !Holiday_List system variable, instead of using the CREATE_HOLIDAYS procedure.

This procedure is called by the CREATE_HOLIDAYS function. Thus, CREATE_HOLIDAYS both creates holidays and makes them available to the PV-WAVE Date/Time routines.

Note that if all weekdays have been defined as weekend days, an error results.

Example

This example shows how you might directly modify the system variable !Holiday_List and then run LOAD_HOLIDAYS to make the change available. Assume that December 26 has been erroneously defined as a holiday and that it is the first Date/Time structure in !Holiday_List. To change this holiday to December 25:

```
!holiday_list(0).DAY = byte(25)
```

Manually change the Day field of the first Date/Time structure in !Holiday_List to the 25th. The Day field of this structure contains a byte value.

```
!holiday_list(0).RECALC = byte(1)
```

Manually set the Recalc field of the structure to 1. This field contains a byte value. See the Caution below.

```
LOAD_HOLIDAYS
```

Run LOAD_HOLIDAYS so the new holiday value will take effect.

Caution Whenever you directly modify the date in a !DT structure, set the `Recalc` field (the last field in the !DT structure) to 1. This causes the Julian date to be recalculated. If the Julian date is not recalculated, plots or Date/Time calculations that use the modified variable may be inaccurate.

See Also

LOAD_WEEKENDS, CREATE_HOLIDAYS, CREATE_WEEKENDS

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV-WAVE User's Guide.*

LOAD_WEEKENDS Procedure

Makes the value of the !Weekend_List system variable available to the Date/Time routines.

Usage

LOAD_WEEKENDS

Parameters

None.

Keywords

None.

Discussion

Run this procedure after you:

- Restore any PV-WAVE session in which you used the CREATE_WEEKENDS function. Running this procedure makes the restored !Weekend_List system variable available to the Date/Time routines.
- Directly change the value of the !Weekend_List system variable, instead of using the CREATE_WEEKENDS procedure.

This procedure is called by the CREATE_WEEKENDS function. Thus, CREATE_WEEKENDS both creates weekends and makes them available to the PV-WAVE Date/Time routines.

Example

```
CREATE_WEEKENDS, 'sat'
```

Create the !Weekend_List system variable and define Saturday as a weekend.

```
PRINT, !Weekend_List
   0    0    0    0    0    0    1
```

Current contents of !Weekend_List system variable.

```
!Weekend_List = [1, 0, 0, 0, 0, 0, 1]
```

Manually add Sunday to the weekend list.

```
LOAD_WEEKENDS
```

Run LOAD_WEEKENDS so the new weekend value will take effect.

See Also

LOAD_HOLIDAYS, CREATE_HOLIDAYS, CREATE_WEEKENDS

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV-WAVE User's Guide*.

LONARR Function

Returns a longword integer vector or array.

Usage

result = LONARR(dim_1, ... , dim_n)

Input Parameters

dim_i — The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result — A longword integer vector or array.

Input Keywords

Nozero — Normally, LONARR sets every element of the result to zero. If *Nozero* is nonzero, this zeroing is not performed, thereby causing LONARR to execute faster.

Example

This example creates a 4-by-2 longword integer array. Note that all elements of the array are initialized to 0L.

```
a = LONARR(4, 2)
```

Create longword integer array.

```
INFO, a
VARIABLE     LONG        = Array(4, 2)

PRINT, a
0   0   0   0
   0   0   0   0
```

See Also

BYTARR, FLTARR, INTARR, LINDGEN

LONG Function

Converts an expression to longword integer data type.

Extracts data from an expression and places it in a longword integer scalar or array.

Usage

result = LONG(*expr*)

This form is used to convert data.

result = LONG(*expr, offset, dim_1* [, ... , *dim_n*])

This form is used to extract data.

Input Parameters

expr — The expression to be converted, or from which to extract data.

offset — (Used to extract data only.) The offset, in bytes, from the beginning of *expr* to where the extraction is to begin.

dim_i — (Used to extract data only.) The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result — (For data conversion.) A copy of *expr* converted to longword integer data type. If no *dim_i* parameters are specified, *result* has the same structure as *expr.*

(For data extraction.) If *offset* is used, LONG does not convert *result,* but allows fields of data extracted from *expr* to be treated as longword integer data.

Keywords

None.

Discussion – Conversion Usage

Caution If the values of *expr* are not within the range of a long integer, a misleading result occurs and a message may be displayed.

For example, suppose `A = 2.0 ^ 31 + 2`. The following commands,

```
B = LONG(A)
C = LONG(–A)
```

produce the erroneous results of

```
B = 2147483647
C = –2147483648
```

In addition, PV-WAVE does not check for overflow during conversion to longword integer data type.

Example

In this example, LONG is used in two ways. First, LONG is used to convert a single-precision, floating-point array to type longword. Next, LONG is used to extract a subarray from the longword array created in the first step.

```
a = FINDGEN(6) + 0.5
```

Create a single-precision, floating-point vector of length 6. Each element has a value equal to its one-dimensional subscript plus 0.5.

```
PRINT, a
0.500000 1.50000 2.50000 3.50000 4.50000
5.50000
```

```
b = LONG(a)
```

Convert a to type longword.

```
INFO, b
VARIABLE      LONG      = Array(6)
```

Note that the floating-point numbers in a were truncated by LONG.

```
PRINT, b
0     1     2     3     4     5
```

Extract the last four elements of b, and place them in a.

```
c = LONG(b, 8, 2, 2)
```

Specify a 2-by-2 long array.

```
INFO, c
VARIABLE     LONG       = Array(2, 2)
```

```
PRINT, c
2         3
4         5
```

See Also

BYTE, COMPLEX, DOUBLE, FIX, FLOAT, LINDGEN, LONARR

For more information on using this function to extract data, see *Extracting Fields* on page 37 of the *PV‑WAVE Programmer's Guide*.

LUBKSB Procedure

Solves the set of *n* linear equations **Ax** = **b**.
(LUBKSB must be used with the procedure LUDCMP to do this.)

Usage

LUBKSB, *a, index, b*

Input Parameters

a – The LU decomposition of a matrix, created by LUDCMP. *a* is not modified by calling this procedure.

index – A vector, created by LUDCMP, containing the row permutations effected by the partial pivoting.

b – On input, *b* contains the vector on the right-hand side of the equation. Must be of data type FLOAT; other data types will cause incorrect output.

Output Parameters

b – On output, *b* is replaced by the solution, vector **x**.

Keywords

None.

Discussion

LUBKSB must be used in conjunction with LUDCMP.

Example

```
Function INNER_PROD, v1, v2

IF N_ELEMENTS(v1) NE 3 THEN goto, error1
IF N_ELEMENTS(v2) NE 3 THEN goto, error1

sum = 0.0
```

```
FOR i=0, 2 DO BEGIN
   sum = sum + v1(i) * v2(i)
END

RETURN, sum

error1:
   PRINT, 'vectors not 3d'
   RETURN, 0
END

arr = FINDGEN(3, 3)
arr(*, 0) = [1.0, -1.0, 3.0]
arr(*, 1) = [2.0, 1.0, 3.0]
arr(*, 2) = [3.0, 3.0, 1.0]
```

Solutions to triplet of equations:

$x + 2y - 2z = 3$

$-x + y - 5z = 0$

$3x + 3y + z = 6$

```
rightvec = [3.0, 0.0, 6.0]


PRINT, ' '
PRINT, 'solving system '
PRINT, arr, '          * [x,y,z] = ', rightvec
PRINT, ' '
PRINT, ' '
tarr = arr
rvec = rightvec
LUDCMP, tarr, index, b
LUBKSB, tarr, index, rvec
PRINT, '... solution for ', rightvec,' $
   is ', rvec
s1 = rvec
PRINT, ' '
PRINT, ' '
PRINT, INNER_PROD(arr(0,*), s1)
PRINT, INNER_PROD(arr(1,*), s1)
```

```
PRINT, INNER_PROD(arr(2,*), s1)

PRINT, ' '
PRINT, ' '

END
```

See Also

LUDCMP, MPROVE

LUBKSB is based on the routine of the same name in *Numerical Recipes in C: The Art of Scientific Computing*, by Flannery, Press, Teukolsky, and Vetterling, Cambridge University Press, Cambridge, MA, 1988. It is used by permission.

LUDCMP Procedure

Replaces an *n-by-n* matrix, *a*, with the LU decomposition of a row-wise permutation of itself.

Usage

LUDCMP, *a, index, d*

Input Parameters

a – An *n-by-n* matrix.

Output Parameters

a – On output, *a* is replaced by the LU decomposition of a row-wise permutation of itself.

index – The vector which records the row permutation effected by the partial pivoting. The values returned for *index* are needed in the call to LUBKSB.

d – An indicator of the number of row interchanges:

+1	Indicates the number was even.
–1	Indicates the number was odd.

Keywords

None.

Example

The preferred method of solving the linear set of equations **Ax = B** is:

```
LUDCMP, A, indx, D
```

Decompose square matrix A.

```
LUBKSB, A, indx, B
```

Use LUBKSB function for forward and back substitution, replacing B with the result x.

See Also

LUBKSB, MPROVE

LUDCMP is based on the routine of the same name in *Numerical Recipes in C: The Art of Scientific Computing*, by Flannery, Press, Teukolsky, and Vetterling, Cambridge University Press, Cambridge, MA, 1988. It is used by permission.

MAKE_ARRAY Function

Returns an array of specified type, dimensions, and initialization. It provides the ability to create an array dynamically whose characteristics are not known until run time.

Usage

result = MAKE_ARRAY([dim_1,... , dim_n])

Input Parameters

***dim**$_i$* – The dimensions of the result. May be any scalar expression. Up to eight dimensions may be specified.

Returned Value

result – An array of specified type, dimensions, and initialization.

Input Keywords

Byte – If nonzero, sets the type of the result to byte.

Complex – If nonzero, sets the type of the result to complex single-precision floating-point.

Dimension – A vector of 1 to 8 elements specifying the dimensions of the result.

Double – If nonzero, sets the type of the result to double-precision floating-point.

Float – If nonzero, sets the type of the result to single-precision floating-point.

Index – The resulting array is initialized with each element set to the value of its one-dimensional index.

Int – If nonzero, sets the type of the result to integer.

Long – If nonzero, sets the type of the result to longword integer.

Nozero — If nonzero, the resulting array is not initialized.

Size — A longword vector specifying the type and dimensions of the result. It consists of the following elements:

- The first element is equal to the number of dimensions of *Value*, and is zero if *Value* is scalar.
- The next elements contain the size of each dimension.
- The last two elements contain the type code and the number of elements in *Value*, respectively. Valid type code values are listed below for the *Type* keyword.

String — If nonzero, sets the type of the result to string.

Type — Sets the type of the result to be the type code entered:

Type Code	Data Type
1	Byte
2	Integer
3	Longword integer
4	Single-precision floating-point
5	Double-precision floating-point
6	Complex floating-point
7	String

Value — Initializes each element of the resulting array with the given value. Can be of any scalar type, including structure types.

Discussion

The result type is taken from the *Value* keyword unless one of the other keywords that specify a type is also used. In that case, *Value* is coerced to be the type specified by this other keyword prior to initializing the resulting array. Note that the resulting type cannot be specified if *Value* is a structure.

If *Value* is specified, all elements in the resulting array are set to *Value*. If *Value* is not specified, all elements are set to zero. If *Index* is specified, each element is set to its index. If *Nozero* is specified, the resulting array is not initialized.

Example

In this example, three different methods are used to create and initialize a 4-by-3 longword integer array.

```
a = MAKE_ARRAY(Size = [2, 4, 3, 3, 12], $
   Value = 5)
```

The type of a is determined by the Size keyword.

```
INFO, a
VARIABLE      LONG          = Array(4, 3)

PRINT, a
5       5       5       5
5       5       5       5
5       5       5       5

b = MAKE_ARRAY(4, 3, Type = 3, Value = 5)
```

The type of b is determined by the Type keyword.

```
INFO, b
VARIABLE      LONG        = Array(4, 3)

PRINT, b
5       5       5       5
5       5       5       5
5       5       5       5
```

The type of c is determined by the Value keyword.

```
c = MAKE_ARRAY(4, 3, Value = 5L)

INFO, c
VARIABLE      LONG          = Array(4, 3)

PRINT, c
5       5       5       5
5       5       5       5
5       5       5       5
```

See Also

SIZE, BYTARR, DBLARR, COMPLEXARR, FLTARR, INTARR, LONARR, BINDGEN, CINDGEN, DINDGEN, FINDGEN, INDGEN, LINDGEN, SINDGEN

MAX Function

Returns the value of the largest element in an input array.

Usage

result = MAX(*array* [, *max_subscript*])

Input Parameters

array – The array to be searched.

max_subscript – The subscript of the maximum element in *array:*

- If supplied, *max_subscript* is converted to a long integer containing the index of the largest element in *array.*
- If *max_subscript* is not supplied, the system variable !C is set to the index of the largest element in the array.

Returned Value

result – The value of the largest element in *array.* The result is given in the same data type as *array.*

Input Keywords

Min – Used to specify a variable to hold the value of the minimum array element.

Tip If you need to find both the minimum and maximum array values, use this keyword to avoid scanning the array twice with separate calls to MAX and MIN.

Example 1

```
x = [22, 40, 9, 12]
PRINT, MAX(x)
   40
```

Example 2

```
x = [3, 4, 5, 6, 7, 8, 9]
maxval = MAX(x, maxindex, Min=minval)
PRINT, maxval
   9
PRINT, maxindex
   6
PRINT, minval
   3
```

See Also

!C, AVG, MEDIAN, MIN

MEDIAN Function

Finds the median value of an array, or applies a one- or two-dimensional median filter of a specified width to an array.

Usage

result = MEDIAN(*array* [, *width*])

Input Parameters

array — The array to be processed. May be of any size, dimension, and data type, except string.

width — The length of the one- or two-dimensional neighborhood to be used for the median filter. Must be a scalar value, greater than 1 and less than the smaller of the dimensions of *array*. The neighborhood will have the same number of dimensions as *array*.

Returned Value

result — The median value for *array*, or *array* after a median filter has been applied to it.

- If *width* is specified and *array* is of a byte data type, the result is also a byte type. All other types are converted to single-precision floating-point, and the result is floating-point. If *width* is used, *array* can have only one or two dimensions.
- If *width* is not specified, *array* may have any valid number of dimensions. It is converted to single-precision floating-point, and the median value is returned as a floating-point value.

Keywords

Average — If specified, and the number of elements in *array* is even, *result* is returned as the average of the two middle values.

Note The *Average* keyword is ignored when filtering a byte array.

Discussion

Median smoothing replaces each point with the median of the one- or two-dimensional neighborhood of the given width. It is similar to smoothing with a boxcar or average filter, but does not blur edges larger than the neighborhood. In addition, median filtering is effective in removing "salt and pepper" noise (isolated high or low values).

The scalar median is simply the middle value, which should not be confused with the average value (e.g., the median of [1, 10, 4] is 4, while the average is 5.)

Example

This example exhibits median filtering of an image that has been corrupted with noise spikes.

```
OPENR, unit, FILEPATH('head.img', $
   Subdir = 'data'), /Get_Lun
```

Open the file containing the human head dataset.

```
head = BYTARR(512, 512)
```

Create an array large enough to hold the dataset.

```
READU, unit, head
FREE_LUN, unit
```

Read the data, then close the file and free the file unit number.

```
slice = CONGRID(REFORM(head), 256, 256, $
   /Interp)
```

Use reform to remove degenerate dimensions, then resize the image using the CONGRID function.

```
WINDOW, 0, Xsize = 768, Ysize = 256
```

Create a window large enough to display three images of the size of the original image.

```
LOADCT, 3
```

Load the red temperature color table.

```
TVSCL, slice, 0
```

Display the original image in the leftmost portion of the window.

```
HIST_EQUAL_CT, slice
```

Histogram equalize the color table.

```
FOR i = 0, 253, 6 DO BEGIN &$
   rows = RANDOM(256) GT 0.5 &$
   k = RANDOM(1) &$
   h = 3 * (k(0) GT 0.5) &$
   FOR j = h, 253, 6 DO BEGIN &$
      IF rows(j) THEN slice(i:i + 2, $
      j:j + 2) = 0 &$
   ENDFOR &$
```

This FOR loop creates 3-by-3 isolated holes in the image.

```
ENDFOR
```

```
TVSCL, slice, 256, 0
```

Display the image with holes in the center portion of the window.

```
filtered = MEDIAN(slice, 5)
```

Median filter the image with holes.

```
TVSCL, filtered, 512, 0
```

Display the median filtered image in the rightmost portion of the window.

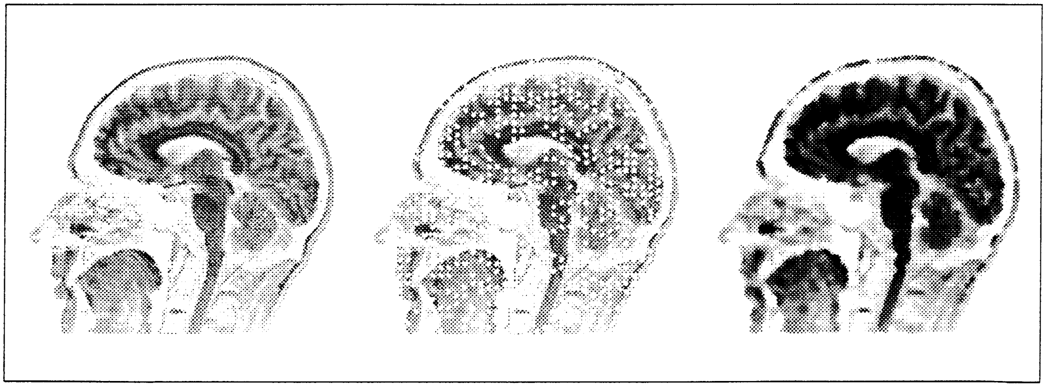


Figure 2-22 Original image (left), corrupted image (center), and median filtered image (right).

See Also

LEEFILT, SMOOTH, AVG, MAX, MIN

MESH Function

Defines a polygonal mesh object that can be used by the RENDER function.

Usage

result = MESH(*vertex_list, polygon_list*)

Input Parameters

vertex_list — A double-precision floating-point array of 3D points; the array's size is 3 * number_of_vertices.

polygon_list — A longword integer 1D array defining the polygons; the array's size is number_of_polygons * number_of_edges.

For more information on these two parameters, see *Vertex Lists and Polygon Lists* on page 187 of the *PV-WAVE User's Guide*.

Returned Value

result — A structure that defines an object consisting of multiple polygons.

Input Keywords

Color — A 256-element double-precision floating-point vector containing the color (intensity) coefficients of the object. The default is `Color(*)=1.0`. For more information, see the section *Defining Color and Shading* on page 198 of the *PV-WAVE User's Guide*.

Decal — A 2D array of bytes whose elements correspond to indices into the arrays of material properties. For more information, see the section *Decals* on page 201 of the *PV-WAVE User's Guide.*

Kamb — A 256-element double-precision floating-point vector containing the ambient (flat shaded) coefficients. The default is `Kamb(*)=0.0`. For more information, see the section *Ambient Component* on page 199 of the *PV-WAVE User's Guide.*

Kdiff — A 256-element double-precision floating-point vector containing the diffuse reflectance coefficients. The default is `Kdiff(*)=1.0`. For more information, see the section *Diffuse Component* on page 198 of the *PV-WAVE User's Guide.*

Ktran — A 256-element double-precision floating-point vector containing the specular transmission coefficients. The default is `Ktran(*)=0.0`. For more information, see the section *Transmission Component* on page 199 of the *PV-WAVE User's Guide.*

Materials — A byte array of size number_of_polygons defining the materials list. The purpose of this keyword is similar to that of the *Decal* keyword for quadric objects. Its use permits the specification of properties for each polygon where each polygon specifies an index into the *Color*, *Kamb*, *Kdiff*, and *Ktran* property arrays.

For more information, see *Defining Object Material Properties* on page 200 of the *PV-WAVE User's Guide.*

Transform — A 4-by-4 double-precision floating-point array containing the local transformation matrix whose default is the identity matrix. For more information, see the section *Setting Object and View Transformations* on page 201 of the *PV-WAVE User's Guide.*

Discussion

MESH can be used by the RENDER function to render collections of 3D polygons, such as iso-surfaces, or spatial-structural data.

Note that any non-coplanar polygons in a mesh are automatically reduced to triangles by RENDER.

The *Transform* keyword can be specified to alter the scaling, as well as the orientation and position of the polygons defined by MESH.

Examples

```
vertices = [[-1.0, -1.0, 1.0],$
           [-1.0,  1.0,  1.0],$
           [ 1.0, 1.0, 1.0],$
           [ 1.0, -1.0, 1.0],$
           [-1.0, -1.0, -1.0],$
           [-1.0, 1.0, -1.0],$
           [ 1.0, 1.0, -1.0],$
           [ 1.0, -1.0, -1.0]]
polygons = [4, 0, 1, 2, 3,$
            4, 4, 5, 1, 0,$
            4, 2, 1, 5, 6,$
            4, 2, 6, 7, 3,$
            4, 0, 3, 7, 4,$
            4, 7, 6, 5, 4]
T3D, /Reset, Rotate=[15, 30, 45]
cube = MESH(vertices, polygons, $
   Transform=!P.T)
TV, RENDER(cube)
```

See Also

CONE, CYLINDER, RENDER, SPHERE, VOLUME

For more information, see *Ray-tracing Rendering* on page 196 of the *PV-WAVE User's Guide.*

For details on the POLYSHADE and SHADE_VOLUME routines, see their descriptions in the *PV-WAVE Reference.*

MESSAGE Procedure

Issues error and informational messages using the same mechanism employed by built-in PV-WAVE routines.

Usage

MESSAGE, *text*

Input Parameters

text – A text string containing the message.

Input Keywords

Continue – If present and nonzero, causes MESSAGE to return after issuing the error instead of taking the action specified by the ON_ERROR procedure. This keyword is useful when it is desirable to report an error and then continue processing.

Noname – Usually, the message includes the name of the issuing routine at the beginning. If *Noname* is present and nonzero, this name is omitted.

Noprefix – Usually, the message includes the message prefix string at the beginning (as specified by the !Msg_Prefix system variable). If *Noprefix* is present and nonzero, this prefix is omitted.

Noprint – If present and nonzero, causes actions to proceed quietly, without the message being printed to the screen. The error system variables are updated as usual.

Output Keywords

Informational – If present and nonzero, specifies that the message is simply informational text, rather than an error, and that processing is to continue. In this case, !Err, !Error, and !Err_String are not set. The !Quiet system variable controls the printing of informational messages.

Ioerror — Indicates that the error occurred while performing I/O. In this case, the action specified by the ON_IOERROR procedure is executed instead of that specified by ON_ERROR.

Traceback — If present and nonzero, provides a traceback message giving the location at which MESSAGE was called. This traceback message follows the output error message.

Discussion

By default, MESSAGE halts execution of your routine; messages are issued as an error and PV-WAVE takes the action specified by the ON_ERROR procedure. However, if you specify either */Continue* or */Informational*, processing of your routine continues uninterrupted.

As a side-effect of issuing the error, the system variables !Err and !Error are set and the text of the error message is placed in the system variable !Err_String.

Example 1

Assume the statement:

```
MESSAGE, 'Unexpected value encountered.'
```

is executed in a procedure named `CALC`. This would cause `CALC` to halt after the following message was issued:

```
% CALC: Unexpected value encountered.
```

Example 2

Assume the statement:

```
MESSAGE, 'Value is greater than 1000; ' + $
   'you will lose some accuracy.', /Noname,$
   /Noprefix, /Informational
```

is executed in a procedure named VERIFY. This would cause the following message to be issued:

```
Value is greater than 1000; you will lose some
   accuracy.
```

and execution would continue to the next line of VERIFY.

See Also

!Err, !Err_String, !Msg_Prefix, HAK, ON_ERROR, ON_IOERROR, WAIT

For more information, see Chapter 4, *System Variables.*

MIN Function

Returns the value of the smallest element in *array.*

Usage

result = MIN(*array* [, *min_subscript*])

Input Parameters

array – The array to be searched.

min_subscript – The subscript of the smallest element in *array*:

- If supplied, *min_subscript* is converted to a long integer containing the one-dimensional subscript of the smallest element.
- If *min_subscript* is not supplied, the system variable !C is set to the one-dimensional subscript of the smallest element.

Returned Value

result – The value of the smallest element in *array*. The result is given in the same data type as *array.*

Input Keywords

Max – Used to specify a variable to hold value of the largest array element.

Tip If you need to find both the minimum and maximum array values, use this keyword to avoid scanning the array twice with separate calls to MAX and MIN.

Example 1

```
x = [22, 40, 9, 12]
PRINT, MIN(x)
   9
```

Example 2

```
x = [3, 4, 5, 6, 7, 8, 9]
minval = MIN(x, minindex, Max=maxval)
PRINT, minval
   3

PRINT, minindex
   0

PRINT, maxval
   9
```

See Also

AVG, MAX, MEDIAN

MODIFYCT Procedure

Standard Library procedure that lets you replace one of the PV-WAVE color tables (defined in the `colors.tbl` file) with a new color table.

Usage

MODIFYCT, *table, name, red, green, blue*

Input Parameters

table – The color table number to change. The numbers range from 0 to 15.

name – The name of the modified color table. The string may be a maximum of 32 characters.

red – The red color gun vector. It contains 256 elements.

green – The green color gun vector. It contains 256 elements.

blue – The blue color gun vector. It contains 256 elements.

Keywords

None.

Discussion

Note Since any changes to the system color tables will affect all users, this procedure should be reserved for a single individual at a PV-WAVE site with authorization to make system modifications. It is also a good idea to make a copy of the `colors.tbl` file prior to using MODIFYCT.

See Also

HLS, HSV, HSV_TO_RGB, LOADCT, RGB_TO_HSV

For more information on customizing color tables, see *Loading Your Own Color Tables: TVLCT* on page 313 of the *PV-WAVE User's Guide.*

MONTH_NAME Function

Standard Library function that returns a string or string array containing the names of the months contained in a Date/Time variable.

Usage

result = MONTH_NAME(*dt_var*)

Input Parameters

dt_var — A PV-WAVE Date/Time variable.

Returned Value

result — A string array containing the name(s) of the months.

Keywords

None.

Discussion

The names of the months are defined as string values in the system variable !Month_List.

Example

```
dttoday = TODAY()
PRINT, dttoday
   { 1992 4 1 6 12 57.0000 87493.259 0}
```

Create a variable that contains PV-WAVE Date/Time data for today's date.

```
m = MONTH_NAME(dttoday)
PRINT, m
   April
```

See Also

DAY_NAME, DAY_OF_WEEK, !Month_Names, !Day_Names

For more information, see Chapter 7, *Working with Date/Time Data*, in the *PV-WAVE User's Guide.*

MOVIE Procedure

Standard Library procedure that shows a cyclic sequence of images stored in a three-dimensional array.

Usage

MOVIE, *images* [, *rate*]

Input Parameters

images – A three-dimensional byte array of image data, consisting of *nframes* images, each dimensioned *n*-by-*m*. Thus, the *images* array is (*n, m, nframes*). This array should be stored with the top row first (i.e., *Order*=1) for maximum efficiency.

rate – The initial rate, in approximate frames per second. If *rate* is omitted, the inter-frame delay is set at 0.01 second.

Input Keywords

Order – Specifies the image ordering:

1	Orders the images from top down (the default).
0	Orders the images from bottom up.

Discussion

The images are displayed in the lower-left corner of the currently selected window.

The rate of display varies with the make of computer, amount of physical memory, and number of frames.

Available memory also restricts the maximum amount of data that can be displayed in a loop.

Example

This example uses MOVIE to cycle through cross-sections of a human head. The *Order* keyword is used to specify that the images are ordered bottom up. The cross-sections are contained in a byte array dimensioned (80, 100, 57).

```
OPENR, unit, FILEPATH('headspin.dat', $
   Subdir = 'data'), /Get_Lun
```

Open the file containing the cross sections.

```
head = BYTARR(256, 256, 32)
```

Create a three-dimensional byte array large enough to contain all cross-sections.

```
READU, unit, head
```

Read the images.

```
FREE_LUN, unit
```

Close the file and free the file unit number.

```
LOADCT, 15
```

Load a color table.

```
MOVIE, head, Order = 0
```

Cycle through the images.

See Also

TV, TVSCL

MPROVE Procedure

Iteratively improves the solution vector, **x**, of a linear set of equations, **Ax** = **b**. (You must call the LUDCMP procedure before calling MPROVE.)

Usage

MPROVE, *a, alud, index, b, x*

Input Parameters

a – An *n-by-n* matrix containing the coefficients of the linear equation **Ax** = **b**.

alud – The LU decomposition of A, an *n-by-n* matrix, as returned by LUDCMP.

index – The vector of permutations involved in the LU decomposition of A, as returned by LUDCMP.

b – An *n*-element vector containing the right-hand side of the set of equations.

x – An *n*-element vector. On input, it contains the initial solution of the system.

Output Parameters

x – An *n*-element vector. On output, it contains the improved solution.

Keywords

None.

See Also

LUDCMP, LUBKSB

MPROVE is based on the routine of the same name in *Numerical Recipes in C: The Art of Scientific Computing*, by Flannery, Press, Teukolsky, and Vetterling, Cambridge University Press, Cambridge, MA, 1988. It is used by permission.

N_ELEMENTS Function

Returns the number of elements contained in any expression or variable.

Usage

result = N_ELEMENTS(*expr*)

Input Parameters

expr — The expression for which the number of elements will be returned.

Returned Value

result — The number of elements contained in any expression or variable.

Scalar expressions always have one element. The number of elements in an array is equal to the product of its dimensions. If *expr* is an undefined variable, N_ELEMENTS will return zero.

Keywords

None.

Example

In this example, N_ELEMENTS is used to determine the number of elements in a two-dimensional array.

```
a = INDGEN(3, 2)
```
Create a 3-by-2 integer array.

```
PRINT, a
0       1       2
3       4       5
```

```
PRINT, N_ELEMENTS(a)
```
Display the number of elements in a.

```
6
```

```
DELVAR, a
```
Delete the variable a.

```
INFO, a
VARIABLE    UNDEFINED = <Undefined>
```

```
PRINT, N_ELEMENTS(a)
0
```

See Also

N_TAGS, N_PARAMS, SIZE, TAG_NAMES

N_PARAMS Function

Returns the number of non-keyword parameters used in calling a PV-WAVE procedure or function.

Usage

result = N_PARAMS( )

Parameters

None.

Returned Value

result — The number of non-keyword parameters used in calling a PV-WAVE procedure or function.

Keywords

None.

Description

N_PARAMS is used to determine if user-written procedures or functions were called with positional (non-keyword) parameters.

See Also

N_TAGS, N_ELEMENTS, SIZE, TAG_NAMES

For more information on functions and procedures, see Chapter 9, *Writing Procedures and Functions*, in the *PV-WAVE Programmer's Guide.*

N_TAGS Function

Returns the number of structure tags contained in any expression.

Usage

result = N_TAGS(*expr*)

Input Parameters

expr — The expression for which the number of structure tags will be returned.

Returned Value

result — The number of structure tags contained in any expression.

Keywords

None.

Discussion

Expressions which are not of structure type are considered to have zero tags. N_TAGS does not search for tags recursively, so if *expr* is a structure containing nested structures, only the number of tags in the outermost structure are counted.

Example

In this example, a structure with three fields is created. Function N_TAGS is applied to the structure and to each field of the structure. The first two fields of the structure are not of type structure. The third field of the structure is of type structure, with two fields.

```
b = {example, t1: [1, 2, 3], t2: 7.0, $
   t3: {field3, t3_t1: 99L, t3_t2: [2, 4, 6]}}

INFO, b, /Structure
```

Create the structure.

```
** Structure EXAMPLE, 3 tags, 32 length:
 T1 INT         Array(3)
 T2 FLOAT       7.00000
 T3 STRUCT      -> FIELD3 Array(1)

PRINT, N_TAGS(b)
```

Display the number of tags in b.

```
3

PRINT, N_TAGS(b.t1)
```

Display the number of tags in each field of b.

```
0

PRINT, N_TAGS(b.t2)
       0

PRINT, N_TAGS(b.t3)
       2
```

See Also

STRUCTREF, TAG_NAMES, SIZE, N_ELEMENTS, N_PARAMS

ON_ERROR Procedure

Determines the action taken when an error is detected inside a PV-WAVE user-written procedure or function.

Usage

ON_ERROR, *n*

Input Parameters

n – An integer that specifies the action to take. Valid values are:

0	Stop at the statement in the procedure that caused the error. (This is the default action.)
1	Return all the way back to the main program level.
2	Return to the caller of the program unit which established the ON_ERROR condition.
3	Return to the program unit which established the ON_ERROR condition.

Keywords

None.

Example

In this example, a procedure named PROC1 calls a procedure, PROC2, which calls either procedure PROC3 or PROC4. Procedure PROC3 contains an error. A call to PRINT from within PROC3 is intended, but a typographical error results in a nonexistent procedure, PAINT, being called. The ON_ERROR procedure, which is called from PROC2, is passed different argument values in this example to exhibit the action taken when the error in PROC3 is encountered.

The following is a listing of the procedures used in this example:

```
PRO PROC1
FOR i = 1, 10 DO BEGIN
   PROC2, i
ENDFOR
END

PRO PROC2, j
ON_ERROR, 0
```

Invoke the ON_ERROR procedure at this point.

```
IF (j MOD 2) EQ 0 THEN BEGIN
   PROC3, j
ENDIF ELSE BEGIN
   PROC4, j
ENDELSE
END

PRO PROC3, k
PAINT, k, ' is even.'
```

The call to a nonexistent procedure, PAINT, occurs here.

```
END

PRO PROC4, m
PRINT, m, ' is odd.'
END
```

Note that ON_ERROR has the argument 0 in PROC2. If the procedures are placed in the file `errex.pro` in your working directory, all of them can be compiled with the following command:

```
.RUN errex
```

Next, invoke the top-level procedure and examine the results:

```
PROC1

       1 is odd.

% Attempt to call undefined
% procedure/function: PAINT.

% Execution halted at PROC3 <errex.pro(21)>.
%       Called from PROC2 <errex.pro(13)>.
%       Called from PROC1 <errex.pro(5)>.
%       Called from $MAIN$.
```

Examine which procedure PV-WAVE returned to by looking at the current nesting of procedures and functions with the INFO command:

```
INFO, /Traceback

% At PROC3 <errex.pro(22)>.
%       Called from PROC2 <errex.pro(13)>.
%       Called from PROC1 <errex.pro(5)>.
%       Called from $MAIN$.
```

PV-WAVE stopped at the PROC3 procedure, where the error occurred. This is where PV-WAVE would have stopped if ON_ERROR had not been called.

If the call to ON_ERROR in PROC2 is changed from

```
ON_ERROR, 0
```

to

```
ON_ERROR, 1
```

then the commands

```
RETALL
.RUN errex
```

need to be executed to return to the main program level and recompile the file containing the example procedures.

To execute PROC1 again and check where PV-WAVE returns after the error in PROC3, issue the following command:

```
PROC1
      1 is odd.

% Attempt to call undefined
% procedure/function: PAINT.

% Execution halted at PROC3 <errex.pro(21)>.
%       Called from PROC2 <errex.pro(13)>.
%       Called from PROC1 <errex.pro(5)>.
%       Called from $MAIN$.

INFO, /Traceback
% Called from $MAIN$.
```

Note that PV•WAVE returned to the main program level.

As a final example, the call to ON_ERROR in PROC2 is changed from

```
ON_ERROR, 1
```

to

```
ON_ERROR, 3
```

and the file containing the example procedures is recompiled and executed with the commands:

```
RETALL

.RUN errex
```

Issue the following command to execute PROC1 again:

```
PROC1
       1 is odd.

% Attempt to call undefined
% procedure/function: PAINT.

% Execution halted at PROC3 <errex.pro(21)>.
%       Called from PROC2 <errex.pro(13)>.
%       Called from PROC1 <errex.pro(5)>.
%       Called from $MAIN$.
```

To see where PV-WAVE returned, issue the following command:

```
INFO, /Traceback
```

```
% Called from PROC2 <errex.pro(13)>.
%       Called from PROC1 <errex.pro(5)>.
%       Called from $MAIN$.
```

Note that this time, PV-WAVE returned to PROC2, which is the program unit that made the call to ON_ERROR.

See Also

ON_IOERROR, OPENR, OPENU, OPENW, READ, RETALL, RETURN, STOP, WRITEU

For more information, see *Error Handling in Procedures* on page 250 of the *PV-WAVE Programmer's Guide.*

Additional information can be found in *Description of Error Handling Routines* on page 258 of the *PV-WAVE Programmer's Guide.*

ON_IOERROR Procedure

Specifies a statement to jump to if an I/O error occurs in the current procedure.

Usage

ON_IOERROR, *label*

Input Parameters

label – The statement to jump to. Note that *label* is not a string variable, but is rather the statement label (without the trailing colon).

Keywords

None.

Discussion

Normally when an input/output error occurs, an error message is printed and program execution is stopped. If ON_IOERROR is called and an I/O related error later occurs in the same procedure activation, control is transferred to the designated statement with the error code stored in the system variable !Err. The text of the error message is contained in the system variable !Err_String.

Example

```
ON_IOERROR, null
```

The effect of ON_IOERROR is canceled by using null as the label.

See Also

!Err, !Err_String, ON_ERROR, OPENR, OPENU, OPENW, READ, RETALL, RETURN, STOP, WRITEU

Additional information can be found in *Description of Error Handling Routines* on page 258 of the *PV-WAVE Programmer's Guide.*

For more information on system variables, see Chapter 4, *System Variables.*

For more information on statement labels, see *Statement Labels* on page 52 of the *PV-WAVE Programmer's Guide.*

For background information, see Chapter 8, *Working with Data Files*, in the *PV-WAVE Programmer's Guide.*

OPEN Procedures (OPENR, OPENU, OPENW)

Open a specified file for input/output:

OPENR (OPEN Read) opens an existing file for input only.

OPENU (OPEN Update) opens an existing file for input and output.

OPENW (OPEN Write) opens a new file for input and output.

Caution When you use OPENW to create a new file under UNIX, if the file exists, it is truncated and its old contents destroyed. Under VMS, a new file with the same name and a higher version number is created.

Usage

OPENR, *unit, filename* [, *record_length*]

OPENU, *unit, filename* [, *record_length*]

OPENW, *unit, filename* [, *record_length*]

Input Parameters

unit – The logical unit number to be associated with the opened file.

filename – The name of the file to be opened. The following differences exist between the UNIX and VMS versions of PV-WAVE regarding wildcard characters and file extensions:

- Under UNIX, the name may contain any wildcard characters recognized by the shell specified by the `SHELL` environment variable. However, it is faster not to use wildcards because PV-WAVE doesn't use the shell to expand filenames unless it has to. No wildcard characters are allowed under VMS.
- Under VMS, filenames that do not have a file extension are assumed to have the `.DAT` extension. No such processing of filenames occurs under UNIX.

record_length – (VMS Only) Specifies the file record size in bytes. This parameter is required when creating new fixed-length files, and is optional when opening existing files:

- If present when creating variable length record files, it specifies the maximum allowed record size.
- If present and no file organization keyword is specified, fixed-length records are implied.

Note Due to limitations in RMS, the length of records must always be an even number of bytes. Therefore, odd record lengths are automatically rounded up to the nearest even boundary.

Input Keywords

Append – If present and nonzero, causes the file to be opened with the file pointer at the end of the file, ready for data to be appended. (Normally, the file is opened with the file pointer at the beginning of the file.) Under UNIX, use of *Append* prevents OPENW from truncating existing file contents.

Block – (VMS only) If present and nonzero, specifies that the file should be processed using RMS block mode. In this mode, most RMS processing is bypassed and PV-WAVE reads and writes to the file in disk block units. Such files can be accessed only via unformatted I/O commands.

Files created in block mode can be accessed only in block mode. Block mode files are treated as an uninterpreted stream of bytes in a manner similar to UNIX stream files.

Note With some controller/disk combinations, RMS does not allow transfer of an odd number of bytes.

Default – (VMS only) A scalar string providing a default file specification from which missing parts of *filename* are taken. For example, to make `.log` be the default file extension and open a new file named `data`, you might enter the following when you open the file:

```
OPENW, 'data', Default='.log'
```

Delete – If present, causes the file to be deleted when it is closed.

Caution Delete will cause the file to be deleted even if it was opened for read-only access. In addition, once a file is opened with this keyword, there is no way to cancel its operation.

Extendsize – (VMS only) If present and nonzero, specifies the number of disk blocks by which *filename* should be extended.

File extension is a relatively slow operation, and it is desirable to minimize the number of times it is done. In order to avoid the unacceptable performance that would result from extending a file a single block at a time, VMS extends its size by a default number of blocks in an attempt to trade a small amount of wasted disk space for better performance.

Extendsize is often used in conjunction with the *Initialsize* and *Truncate_On_Close* keywords.

Fixed – (VMS only) Specifies that the file has fixed-length records. The *Record_Size* parameter is required when opening new fixed-length files. For example:

```
OPENW, 1, 'data', /Fixed, 512
```

Fortran – (VMS only) Specifies that FORTRAN-style carriage control will be used when you create a new file.

F77_Unformatted – (UNIX only) If present and nonzero, specifies that PV-WAVE is to read and write extra information in the same manner as F77. This allows data to be processed by both FORTRAN and PV-WAVE.

Unformatted, variable-length record files produced by UNIX FORTRAN programs contain extra information along with the data in order to allow the data to be properly recovered. This is necessary because FORTRAN is based on record-oriented files, while UNIX files are simple byte streams that do not impose any record structure.

Get_Lun – If present and nonzero, calls the GET_LUN procedure to set the value of *unit* before the file is opened. Thus, the two statements:

```
GET_LUN, unit
OPENR, unit, 'data.dat'
```

can be written as:

```
OPENR, unit, 'data.dat', /Get_Lun
```

Initialsize – (VMS only) Specifies the initial size of the file allocation in blocks. This keyword is often used in conjunction with the *Extendsize* and *Truncate_On_Close* keywords.

Keyed – (VMS only) Specifies that the file has indexed organization.

List – (VMS only) Specifies that carriage return carriage control will be used when you create a new file. If no other carriage control keyword is specified, *List* is the default.

More – (Under VMS, allowed only with stream files.) If present and nonzero, and the specified *filename* is a terminal, formats all output to the specified *unit* in a manner similar to the UNIX `more` command. Output pauses at the bottom of each screen, at which point you can press one of the following keys:

<Space>	Causes the next page of text to be displayed.
<Return>	Causes the next line of text to be displayed.
<Q>	Suppresses all following output.
<H>	Displays the list of available options at this point.

For example, the following statements show how to output a file named `text.dat` to the terminal:

```
OPENR, inunit, 'text.dat', /Get_Lun
    Open the text file.

OPENW outunit, '/dev/tty', /Get_Lun, /More
    Open the terminal as a file.

line = '' & readf, inunit, line
    Read the first line.

while not eof(inunit) do begin
    printf, outunit, line
    readf, inunit, line
        While there is text left, output it.

    ENDWHILE

FREE_LUN, inunit & FREE_LUN, outunit
    Close the files and deallocate the units.
```

None – (VMS only) Specifies that explicit carriage control will be used when you create a new file. This means that VMS does not add any carriage control information to the file, and you must explicitly add any desired carriage control to the data being written to the file.

Print – (VMS only) If present, sends the file to `SYS$PRINT` (the default system printer) when it is closed.

Segmented – (VMS only) Specifies that the file has VMS FORTRAN-style segmented records. Segmented records allow logical records to exist with record sizes that exceed the maximum possible physical record sizes supported by VMS. Segmented record files are useful primarily for passing data between FORTRAN and PV-WAVE programs.

Shared – (VMS only) If present, allows other processes read and write access to the file in parallel with PV-WAVE. If *Shared* is not present, read-only files are opened for read sharing and read/write files are not shared.

Caution **It is not a good idea to allow shared write access to files open in** RMS block mode. In block mode, VMS cannot perform the usual record locking which avoids file corruption. It is therefore possible for multiple writers to corrupt a block mode file. This same warning also applies to fixed-length-record disk files, which are also processed in block mode.

Stream – (VMS only) Specifies that the file will be opened in stream mode.

Submit – (VMS only) If present, specifies that the file will be submitted to `SYS$BATCH` (the default system batch queue) when it is closed.

Truncate_On_Close – (VMS only) If present, causes any unused disk space allocated to the file to be freed when the file is closed. This keyword can be used to get rid of excess allocations caused by the *Extendsize* and *Initialsize* keywords.

Truncate_On_Close has no effect if the *Shared* keyword is present, or if the file is open for read-only access.

Variable – (VMS only) Specifies that the file has variable-length records. If the *record_size* parameter is present, this keyword specifies the maximum record size. Otherwise, the only limit is that imposed by RMS (32,767 bytes). If no file organization is specified, variable-length records are the default.

Width – Specifies the desired width for output. If this keyword is not present, PV-WAVE uses the following rules to determine where to break lines:

- If the output file is a terminal, the terminal width is used.
- Under VMS, if the file has fixed-length records or a maximum record length, the record length is used.
- If neither condition above applies, a default of 80 columns is used.

XDR – (Under VMS, allowed only with stream files.) If present and nonzero, opens the file for unformatted XDR (eXternal Data Representation) input/output via the READU and WRITEU procedures.

Using this keyword makes binary data portable across different machine architectures by reading and writing all data in a standard format. When a file is open for XDR access, the only I/O data transfer procedures that can be used with it are READU and WRITEU.

Output Keywords

Error – If present and nonzero, specifies a named variable into which the error status should be placed. (If an error occurs in the attempt to open *filename*, PV-WAVE normally takes the error handling action defined by ON_ERROR and/or ON_IOERROR.)

The OPEN procedures always return to the caller without generating an error message when *Error* is present. A nonzero error status indicates that an error occurred. The error message can then be found in the system variable !Err_String.

For example, statements similar to the following can be used to detect errors:

```
OPENR, 1, 'demo.dat', Error= err
```

Try to open the file demo.dat.

```
IF (err NE 0) then PRINTF, -2, !Err_String
```

If err is nonzero, something happened, so print the error message to the standard error file (logical unit –2).

Example

This example uses OPENR to open the `head.img` file for reading. This file is in the subdirectory `data`, under the main PV-WAVE distribution directory. The image is read from the file, and the file is closed.

```
OPENR, unit, FILEPATH('head.img', $
   Subdir = 'data'), /Get_Lun
```

Open head.img for reading.

```
ct = BYTARR(512, 512)
```

Create a 256-by-256 byte array to hold the image.

```
READU, unit, ct
```

Read the image.

```
FREE_LUN, unit
```

Close head.img and free the file unit number associated with it.

See Also

!Err, !Err_String, FREE_LUN, GET_LUN, ON_ERROR, ON_IOERROR, POINT_LUN, READ, WRITEU

For background information, see Chapter 8, *Working with Data Files*, in the *PV-WAVE Programmer's Guide*.

For more information on XDR, see *External Data Representation (XDR) Files* on page 205 of the *PV-WAVE Programmer's Guide*.

OPLOT Procedure

Plots vector data over a previously drawn plot.

Usage

OPLOT, *x* [, *y*]

Input Parameters

x – A vector. If only one parameter is supplied, *x* is plotted on the Y axis as a function of point number.

y – A vector. If two parameters are supplied, *y* is plotted as a function of *x*.

Keywords

OPLOT keywords are listed below. For a description of each keyword, see Chapter 3, *Graphics and Plotting Keywords*.

Background	Psym	XTicks	YTitle
Channel	Subtitle	XTickv	YType
Charsize	Symsize	XTitle	
Charthick	T3d	XType	ZCharsize
Clip	Thick		ZGridstyle
Color	Tickformat	YCharsize	ZMargin
Data	Ticklen	YGridstyle	ZMinor
Device	Title	YMargin	ZRange
Font		YMinor	ZStyle
Gridstyle	XCharsize	YNozero	ZTickformat
Linestyle	XGridstyle	YRange	ZTicklen
Noclip	XMargin	YStyle	ZTickname
Nodata	XMinor	YTickformat	ZTicks
Noerase	XRange	YTicklen	ZTickv
Normal	XStyle	YTickname	ZTitle
Nsum	XTickformat	YTicks	ZValue
Polar	XTicklen	YTickv	
Position	XTickname		

Discussion

OPLOT differs from PLOT only in that it does not generate a new axis. Instead, it uses the scaling established by the most recent call to PLOT and simply overlays a plot of the data on the existing axis. Each call to PLOT establishes the plot window (the region of the display enclosed by the axes), the axis types (linear or log), and the scaling. This information is saved in the system variables !P, !X, and !Y, and used by subsequent calls to OPLOT.

Example

In this example, 10 random points are plotted as square markers using the PLOT procedure. Procedure OPLOT is then used to plot a cubic spline interpolant to the random points. The square markers at the random points remain in the plotting window when the interpolant is plotted because OPLOT draws over what is already in the plotting window. This example uses the PV-WAVE Advantage functions CSINTERP, RANDOMOPT, RANDOM, and SPVALUE.

```
RANDOMOPT, Set = 45321
```

Create a vector of 10 random values.

```
x = RANDOM (10)
PLOT, x, Psym = 6
```

Plot the random points as a function of vector index. Use square marker symbols to represent the data points.

```
pp = CSINTERP(FINDGEN(10), x)
```

```
ppval = SPVALUE(FINDGEN(100)/10, pp)
```

Compute the cubic spline interpolant.

```
OPLOT, FINDGEN(100)/10, ppval
```

Plot the interpolant over the marker symbols.

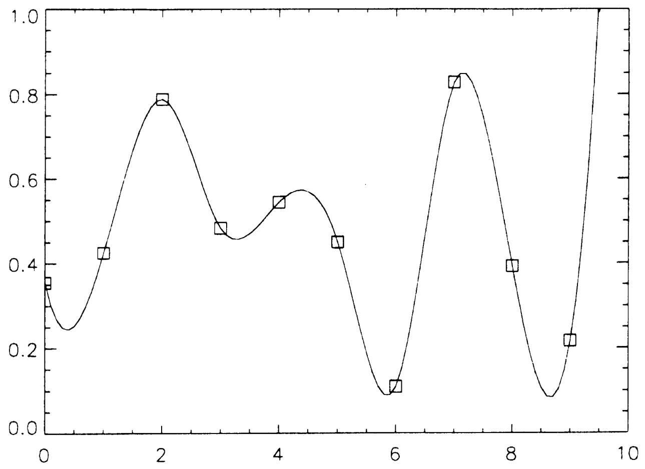


Figure 2-23 Overplotting a plot.

See Also

PLOT, PLOTERR, OPLOTERR

For more information, see Chapter 3, *Displaying 2D Data*, in the *PV-WAVE User's Guide.*

OPLOTERR Procedure

Standard Library procedure that overplots symmetrical error bars on any plot already output to the display device.

Usage

OPLOTERR, *x*, *y*, *error* [, *psym*]

Input Parameters

x – A real vector containing the X coordinates of the data to plot. If not present, *x* is assumed to be a vector of the same size as *y* and to have integer values beginning at 0 and continuing to the size of *y* – 1.

y – A real vector containing the Y coordinates of the data to plot.

error – A vector containing the symmetrical error bar values at every element in *y*.

Psym – Specifies the plotting symbol to use. It corresponds to the PV-WAVE system variable !Psym. If not specified, the default is 7 (the symbol "X").

Keywords

None.

Example 1

To plot error bars over the x and y vectors, with symbols at the data values, use the following commands:

```
x = [1, 2, 3, 4]
y = [2, 1, 3, 2]
PLOT, x, y
error = [0.5, 0.25, 1, 0]
psym = 6
OPLOTERR, x, y, error, psym
```

This produces the plot below:

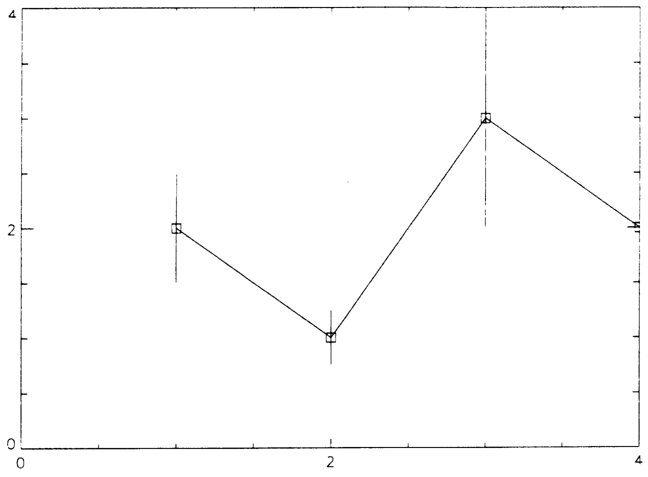


Figure 2-24 In this example, OPLOTERR was used to plot error bars over the x and y vectors, using the square symbol at the data values.

Example 2

This example plots a B-spline interpolant to some scattered data. The data points, along with error bars extending one unit on either side of the data points, are then plotted on top of the interpolant. This example uses PV-WAVE Advantage function BSINTERP.

```
x = INDGEN(7) + 1
```

Generate the abscissas.

```
y = [2, 4, 5, 7, 6, 8, 12]
```

Create a vector of ordinates.

```
bs = BSINTERP(x, y)
```

Compute the B-spline interpolant.

```
bsval = SPVALUE(FINDGEN(100)/5, bs)
```

Plot the interpolant.

```
PLOT, FINDGEN(100)/5, bsval, $
   Xrange = [0, 8], Yrange = [0, 13]
```

```
err = MAKE_ARRAY(7, Value = 1)
```

Create the error bar vector.

```
OPLOTERR, x, y, err, 6
```

Overplot the data points, using square marker symbols and the error bars.

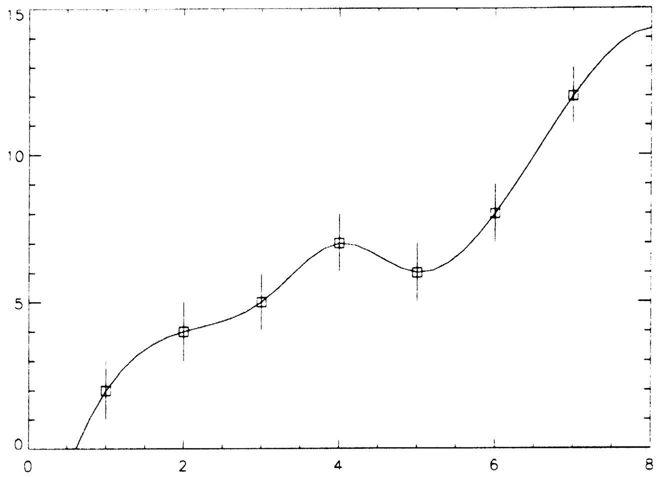


Figure 2-25 Scattered data interpolant with overplotted data points and symmetric error bars.

See Also

ERRPLOT, PLOTERR, !P.Psym

PALETTE Procedure

Standard Library procedure that lets you interactively create a new color table based on the RGB color system.

Usage

PALETTE [, *colors_out*]

Input Parameters

None.

Output Parameters

colors_out – Contains the color values of the final color table in the form of a two-dimensional array that has the number of colors in the color table as the first dimension and the integer 3 as the second dimension.

The values for red are stored in the first row, the values for green are stored in the second row, and those for blue in the third row; in other words:

red = colors_out(, 0)*
green = colors_out(, 1)*
blue = colors_out(, 2)*

Keywords

None.

Discussion

PALETTE works only on displays with window systems. It creates an interactive window that lets you use the mouse to create a new color table. This window is shown in Figure 2-26.

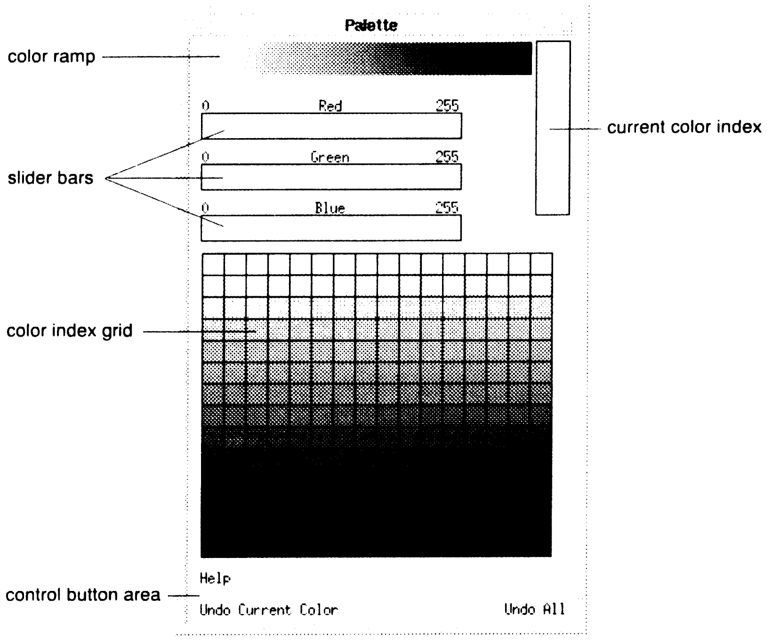


Figure 2-26 The PALETTE window lets you use the mouse to create a new color table interactively.

The PALETTE window contains the following items:

- **Color Ramp** — Displays the current color table.
- **Slider Bars** — Used to adjust the color values of the selected color index.
- **Color Index Grid** — Contains a representation of each color index that comprise the current color table. There are three rectangular slider bars for the red, green, and blue color vectors. The grid is used to select a color index to adjust and to create a new color ramp. The number of color indices that appear in the grid depend on the number of colors selected with the WINDOW procedure.
- **Control Button Area** — Contains buttons for selecting Help, Undo Current Color, and Undo All. To select a button, click it with the left mouse button.

The **Help** button displays information about the procedure in the main PV-WAVE window

The **Undo All** button resets all color indices to their default values.

The **Undo Current Color** button resets the currently selected color index to its default value.

You can modify any number of color indices, or produce an interpolation between two modified color indices. The default color table is the currently loaded color table.

For information on using the PALETTE window, select the **Help** button and follow the online instructions provided.

Example 1

```
TVSCL, LINDGEN(256, 256)
PALETTE, rgb_array
```

— User modifies the color table and exits the procedure. —

```
SAVE, filename='my_colortable', rgb_array
LOADCT, 2
RESTORE, 'my_colortable'
rgb_array = REFORM(rgb_array, $
   N_ELEMENTS(rgb_array)/3, 3)
TVLCT, rgb_array(*,0), rgb_array(*,1), $
   rgb_array(*,2)
```

Example 2

```
TVSCL, LINDGEN(256,256)
PALETTE
```

— User modifies the color table and exits the procedure. —

```
TVLCT, r, g, b, /Get
SAVE, filename='my_colortable_2', r, g, b
LOADCT, 8
RESTORE, 'my_colortable_2'
TVLCT, r, g, b
```

See Also

COLOR_CONVERT, COLOR_EDIT, MODIFYCT, PALETTE, WgCeditTool

For more ideas about what can be done with color tables, see *Modifying the Color Tables* on page 314 of the *PV-WAVE User's Guide.*

PLOT Procedures (PLOT, PLOT_IO, PLOT_OI, and PLOT_OO)

Produce a 2D graph of vector parameters:

PLOT produces a simple XY plot.

PLOT_IO produces an XY plot with logarithmic scaling on the Y axis.

PLOT_OI produces an XY plot with logarithmic scaling on the X axis.

PLOT_OO produces an XY plot with logarithmic scaling on both the X and Y axes.

Usage

PLOT, *x* [, *y*]

PLOT_IO, *x* [, *y*]

PLOT_OI, *x* [, *y*]

PLOT_OO, *x* [, *y*]

Input Parameters

x – A vector. If only one parameter is supplied, *x* is plotted on the Y axis as a function of point number.

y – A vector. If two parameters are supplied, *y* is plotted as a function of *x*.

Keywords

Valid keywords for the four PLOT procedures are listed below. For a description of each keyword, see Chapter 3, *Graphics and Plotting Keywords*.

Background	Normal	XRange	YTickname
Box	Nsum	XStyle	YTicks
Channel	Polar	XTickformat	YTickv
Charsize	Position	XTicklen	YTitle
Charthick	Psym	XTickname	YType
Clip	Start_Level	XTicks	
Color	Subtitle	XTickv	ZCharsize
Compress	Symsize	XTitle	ZGridstyle
Data	T3d	XType	ZMargin
Device	Thick		ZMinor
DT_Range	Tickformat	YCharsize	ZRange
Font	Ticklen	YGridstyle	ZStyle
Gridstyle	Title	YMargin	ZTickformat
Linestyle	Week_Boundary	YMinor	ZTicklen
Max_Levels		YNozero	ZTickname
Month_Abbr	XCharsize	YRange	ZTicks
Noclip	XGridstyle	YStyle	ZTickv
Nodata	XMargin	YTickformat	ZTitle
Noerase	XMinor	YTicklen	ZValue

Example 1

This example shows the most common way to use the PLOT procedure.

```
x = FINDGEN(37) * 10
y = SIN(x * !Dtor)
```

Create a sine wave from 0 to 360 degrees.

```
PLOT, y
```

Plot the sine wave using the default values for the plotting keywords.

```
PLOT, x, y, XRange=[0, 360], Title='SIN(X)', $
   XTitle='degrees', YTitle='sin(x)'
```

Plot the sine wave against the X values, change the range of the X axis, and add labels. Notice that PV-WAVE rounds the requested range values on the axis to values that give a nice looking plot — in this case 0 to 400.

```
PLOT, x, y, XRange=[0, 360], XStyle=1, $
   XTicks=6, XMinor=6, XTitle='!8degrees', $
   YTitle='!8sin(x)!3', Title='!17SIN(X)'
```

Use keywords to get the desired style and to add fonts to the labels.

```
PLOTS, [0, 360], [0, 0]
```

Plot a base line at 0.

```
TEK_COLOR
```

Set up a predefined color table called tek_color.

```
POLYFILL, x(0:18), y(0:18), Color=6
```

Fill under the positive half of the curve with solid magenta.

```
z = COS(x * !Dtor)
```

Calculate the cosine of x.

```
OPLOT, x, z, Linestyle=2, Color=3, Thick=4
```

Plot the cosine using a thick, dashed line and a different color.

Example 2

This example creates a logarithmic plot.

```
x = [100, 5000, 20000, 50000, 70000L]
y = [100, 10000, 1100000L, 100000L, 200000L]
```

Create the data.

```
PLOT_OO, x, y, Ticklen=0.5, Gridstyle=1,$
   Tickformat='(I7)', Title='TEST PLOT', $
   YRange=[1.e2, 1.e7], YStyle=1
```

Plot the data on a log-log plot, with dotted grid lines. Use a format of I7 for the plot labels.

```
max_y = MAX(y)
```

Get the maximum value of y.

```
x_max_y = x(WHERE(y EQ max_y))
```
Get the value for x when y is at its maximum.

```
XYOUTS, x_max_y(0), max_y+1.e5, 'Test Max', $
   Alignment=0.5
```
Print "Test Max" centered at the maximum point.

Example 3

In this example, the cubic spline interpolant to the function

$$f(x) = 1000\sin(1/x^2) + \cos(10x)$$

over the interval $[1, 21]$ is plotted using PLOT_IO. This example uses the PV-WAVE Advantage function CSINTERP.

```
x = FINDGEN(101)/5 + 1
```
Generate the abscissas.

```
y = 1000 * SIN(1/x^2) + COS(10 * x)
```
Generate the function values.

```
pp = CSINTERP(x, y)
```
Compute the cubic spline interpolant.

```
ppval = SPVALUE(FINDGEN(1001)/50 + 1, pp)
```

```
PLOT_IO, FINDGEN(1001)/50 + 1, ppval
```
Plot the result with logarithmic scaling on the y-axis.

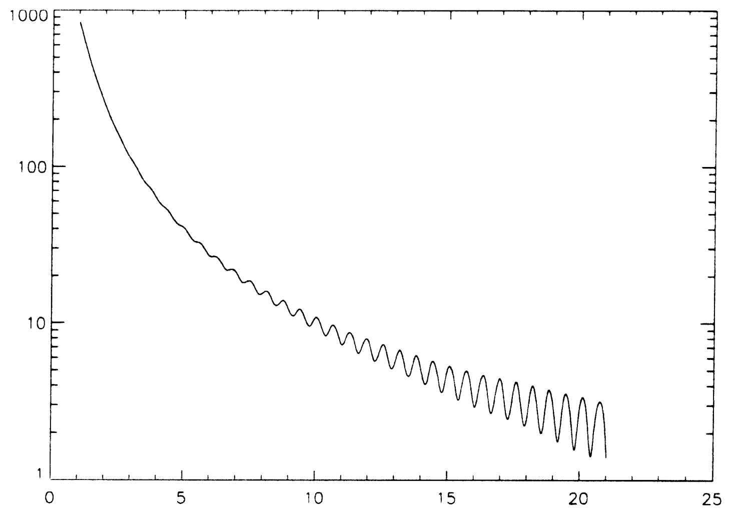


Figure 2-27 PLOT_IO plot of $f(x) = 1000 \sin(1/x^2) + \cos(10x)$.

Example 4

This example uses the PV-WAVE Advantage SPVALUE function.

```
x = FINDGEN(100) * 10
```
Generate the abscissas.

```
y = x + 100 * COS(0.05 * x)
```
Generate the function values.

```
pp = CSINTERP(x, y)
```
Compute the cubic spline interpolant.

```
ppval = SPVALUE(FINDGEN(1000), pp)
```

```
PLOT_OI, FINDGEN(1000), ppval, $
   Xrange = [10, 1000]
```
Plot the result with logarithmic scaling on the x-axis.

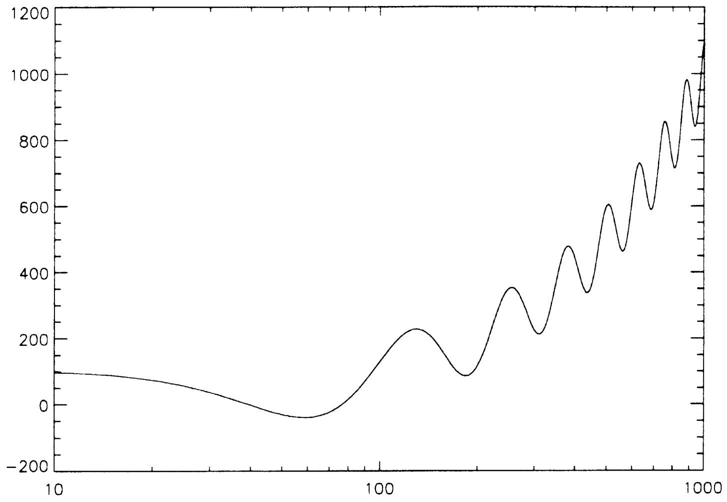


Figure 2-28 PLOT_OI plot of $f(x) = x + 100 \cos (0.05x)$.

Example 5

This example creates a polar plot.

```
theta = (FINDGEN(200)/100) * !Pi
r = 2 * SIN(4 * theta)
```

Create the data.

```
PLOT, r, theta, /Polar, XStyle=4, YStyle=4, $
   Title='POLAR PLOT TEST'
```

Display a polar plot, disabling the box style axis.

```
AXIS, 0, 0, XAxis=0
```

Draw an X axis at the point 0, 0 with tick marks going down.

```
AXIS, 0, 0, YAxis=0
```

Draw a Y axis at the point 0, 0 with tick marks going left.

Example 6

This example creates a plot with multiple axes.

```
temperature = [50., 40., 35., 60., 40.]
pressure = [1025, 1020, 1015, 1026, 1022]
```

Create the data.

```
PLOT, temperature, YRange=[20., 70], $
   YTitle='Degrees Fahrenheit', $
   XTitle='Sample Number', $
   Title='Sample Data', XMargin=[8, 8], $
   YStyle=8, Color=16
```

Plot temperature against scale on the left axis.

```
AXIS, YAxis=1, YRange=[1000, 1040], YStyle=1,$
   YTitle='Air Pressure', /Save, Color=16
```

Create the axis for air pressure.

```
OPLOT, pressure, Linestyle=2, Color=6
```

Plot air pressure against scale on the right axis.

```
LEGEND, ['temperature', 'air pressure'], $
   [16, 6], [0, 2], [0, 0], 2.4, 1005, 2
```

Display a legend.

Example 7

This example creates a plot with a Date/Time X axis.

```
x = VAR_TO_DT(1992,1,1)
```

Create a date-time array with the first day of 1992.

```
x = DTGEN(x, 12, /Month)
```

Create an array of date lines with one value for each month.

```
y = RANDOMU(seed, 12) * 1000
```

Create an array of data values ranging from 0 to 1000.

```
PRINT, !Month_names
hold_month_names = !Month_names
```

Print the current names for months, and then save them.

```
FOR i = 0, 11 DO !month_names(i) = $
   STRMID(!month_names(i), 0, 3)
```

Change the names to be 3-letter abbreviations for the months.

```
ylabels = STRARR(6)
```

```
FOR i = 0, 5 DO ylabels(i)='$' + $
   STRTRIM(string(100L * i * 2), 2)
```

Create labels on the Y axis that start with a '$'.

```
PLOT, x, y, /Month_abbr, /Box$
   Title='Test Date Plot', YRange=[0, 1000],$
   YStyle=1, YTickname=ylabels, YTicks=5,$
   YTitle='In thousands', YGridstyle=1, $
   YTicklen=0.5
```

Plot the data.

```
!Month_names = hold_month_names
```

Restore !Month_names to the original.

See Also

AXIS, OPLOT, OPLOTERR, PLOTERR, PLOTS, XYOUTS

For background information, see Chapter 3, *Displaying 2D Data*, in the *PV-WAVE User's Guide.*

PLOTERR Procedure

Standard Library procedure that plots data points with accompanying symmetrical error bars.

Usage

PLOTERR, [*x*,] *y*, *error*

Input Parameters

x – A real vector containing the X coordinates of the data to plot. If not present, *x* is assumed to be a vector of the same size as *y* and to have integer values beginning at 0 and continuing to the size of $y - 1$.

y – A real vector containing the Y coordinates of the data to plot.

error – A vector containing the error bar values of every point to be plotted.

Input Keywords

Psym – The plotting symbol to use. If not specified, the default is 7 (the symbol "X"). *Psym* corresponds to the system variable !Psym. See Chapter 3, *Graphics and Plotting Keywords*, for a complete description of the *Psym* graphics keyword.

Type – Specifies the type of plot to produce. Valid values are:

0	X Linear, Y Linear (the default)
1	X Linear, Y Log
2	X Log, Y Linear
3	X Log, Y Log

Discussion

PLOTERR produces a plot of *y* versus *x*, with error bars drawn from *y* – *error* to *y* + *error*.

Example

Assume that vector y contains the data values to be plotted, and that `error` is the vector containing the error bar values. The PV-WAVE commands to plot the data points with accompanying symmetrical error bars are:

```
y = [2, 1, 3, 3, 1]
error = [0.0, 0.5, 1.0, 0.5, 0.0]
PLOTERR, y, error, Psym=4
```

To overplot a line through the error bar, enter the following command:

```
OPLOT, y
```

This produces the plot below:

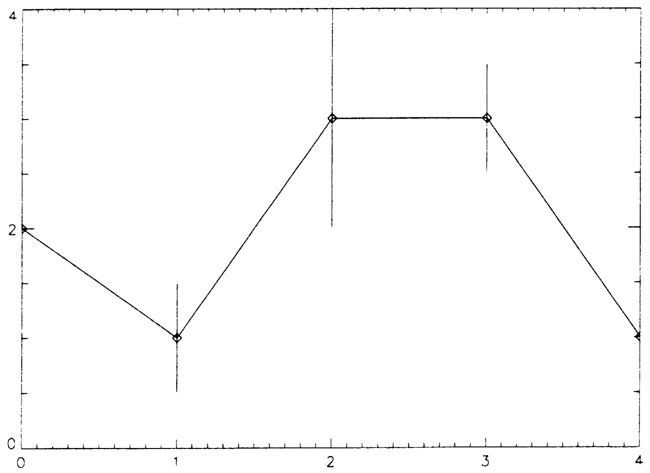


Figure 2-29 In this example, PLOTERR was first used to plot data points with their accompanying symmetrical error bars, and then OPLOT was used to overplot a line through the error bar.

See Also

ERRPLOT, OPLOT, OPLOTERR, PLOT

PLOT_FIELD Procedure

Standard Library procedure that plots a two-dimensional velocity field.

Usage

PLOT_FIELD, *u, v*

Input Parameters

u – A two-dimensional array giving the field vector at each point along the X axis.

v – A two-dimensional array giving the field vector at each point along the Y axis.

Input Keywords

Aspect – The aspect ratio of the final plot; that is, the ratio of the length of X axis to the length of the Y axis. The default is 1.

Length – The length of the longest field vector, expressed as a fraction of the plotting area. The default is 0.1.

N – The number of arrows to draw. The default is 200.

Title – A string containing the title of the plot. The default is "Velocity Field".

Discussion

PLOT_FIELD picks *N* points at random and traces a path from each point along the field. The length of the path is proportional to *Length* and the field vector magnitude at that point.

Caution Extra care must be taken if you run the PLOT_FIELD and VEL procedures in the same PV-WAVE session. Each procedure calls a routine named ARROWS, but the ARROWS routines are slightly different. If you get an error in the ARROWS routine when you are using PLOT_FIELD, recompile PLOT_FIELD (by typing `.run PLOT_FIELD`), and then try again.

Example

```
u = FLTARR(21, 21)
v = FLTARR(21, 21)
```

Create the arrays.

```
.RUN
```

After you type .RUN, the PV-WAVE prompt WAVE> will change to a dash (–) to indicate that you may enter a complete program unit.

```
- FOR j = 0, 20 DO BEGIN

- FOR i = 0, 20 DO BEGIN
- x = 0.05 * FLOAT(i)
- z = 0.05 * FLOAT(j)
- u(i, j) = -SIN(!Pi * x) * COS(!Pi * z)
- v(i, j) =  COS(!Pi * x) * SIN(!Pi * z)
- ENDFOR
- ENDFOR
- END
```

This procedure puts values into the array. The last END exits you from programming mode, compiles and executes the procedure, and then returns you to the WAVE prompt.

```
PLOT_FIELD, u, v
```

Display the velocity field with default values.

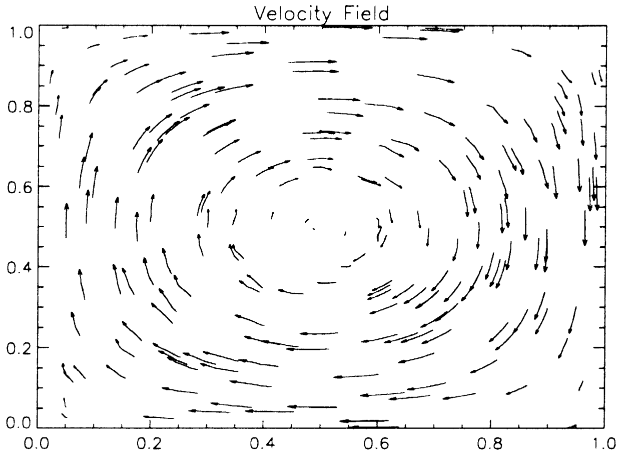


Figure 2-30 Velocity field displayed with default values.

```
PLOT_FIELD, u, v, N=400
```

Display the velocity field using 400 arrows.

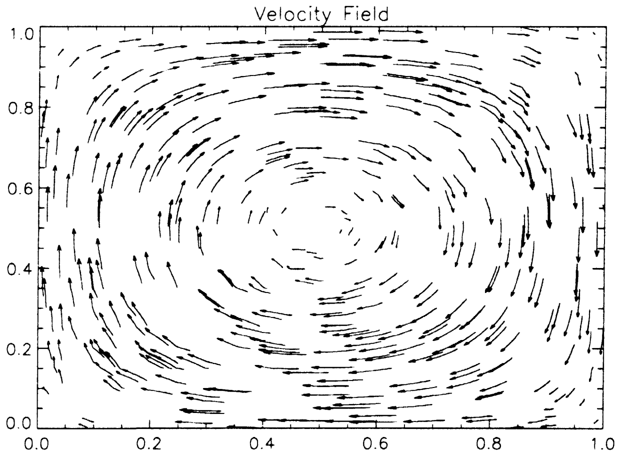


Figure 2-31 Velocity field displayed with 400 arrows.

```
PLOT_FIELD, u, v, Aspect=.7, Length=.4, N=20,$
   Title='Example of PLOT_FIELD'
```

Display the velocity field with individual modifications.

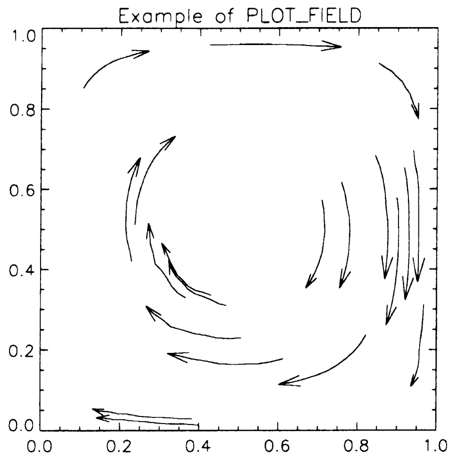


Figure 2-32 Velocity field modified with various keywords.

See Also

VEL, VELOVECT

PLOTS Procedure

Plots vectors or points on the current graphics device in either two or three dimensions.

Usage

PLOTS, *x* [, *y* [, *z*]]

Input Parameters

x — A vector parameter providing the X coordinates of the points to be connected.

If only one parameter is specified, *x* must be an array of either two or three vectors: `(2,*)` or `(3,*)`. In this special case, `x(0,*)` is taken as the X values, `x(1,*)` is taken as the Y values, and `x(2,*)` is taken as the Z values.

y — A vector parameter providing the Y coordinates of the points to be connected.

z — If present, a vector parameter providing the Z coordinates of the points to be connected. If *z* is not specified, *x* and *y* are used to draw lines in two dimensions. *z* has no effect if the keyword *T3D* is not specified and the system variable !P.T3d = 0.

Keywords

PLOTS keywords are listed below. For a description of each keyword, see Chapter 3, *Graphics and Plotting Keywords.*

Channel	Fill_Pattern	Orientation	T3d
Clip	Linestyle	Pattern	Thick
Color	Line_Fill	Psym	Z
Data	Noclip	Spacing	
Device	Normal	Symsize	

Discussion

A valid data coordinate system must be established before PLOTS is called. (A call to PLOT can be used to establish this coordinate system.) Also note that a PV-WAVE window must be open and selected when the call to PLOTS is made for the procedure to work correctly.

The coordinates for PLOTS can be given in data, device, or normalized form using the *Data, Device*, or *Normal* keywords.

Example 1

```
WINDOW
xdata = [.1, .2, .5, .8, .9, .5]
ydata = [.3, .6, .9, .6, .3, .1]
PLOTS, xdata, ydata
PLOTS, xdata, ydata, /Normal
PLOTS, xdata, ydata, Symsize=5.0, Psym=-1,$
   /Normal
```

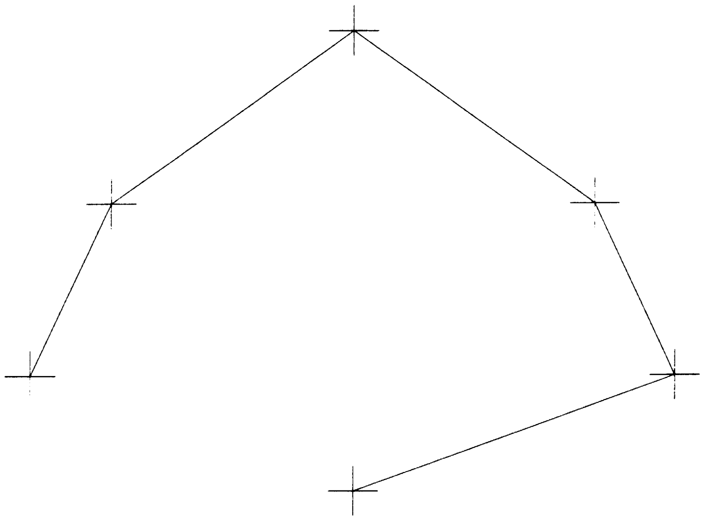


Figure 2-33 Connected lines drawn with PLOTS.

Example 2

This example plots a curve in $\mathbb{R}^2$. Notice that PLOT is first called to set up the two-dimensional coordinate system. Normally, PLOT would be called to perform the entire plot, but for demonstration purposes, PLOTS is used to complete the plot once the coordinate system has been defined.

```
PLOT, FINDGEN(2), /Nodata, $
   Xrange = [-1, 1], Yrange = [-1, 1]
```

Set up the axes using PLOT.

```
p = FINDGEN(1000)/999
```

Generate data.

```
x = p * SIN(50 * p)
y = p * COS(50 * p)

PLOTS, x, y
```

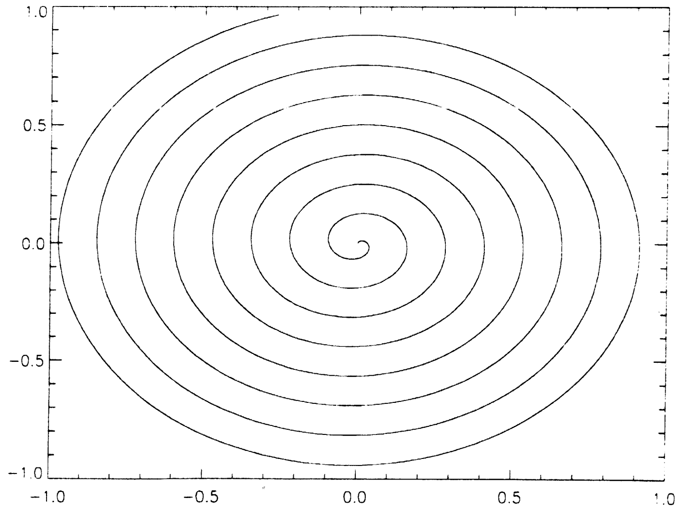


Figure 2-34 Plot of curve in $\mathbb{R}^2$ using PLOT S.

Example 3: Line Plot in $\mathbb{R}^3$

This example plot a curve in $\mathbb{R}^3$. Notice that SURFACE is called initially to set up the three-dimensional coordinate system. It is also important to note that keywords *Nodata* and *Save* are used when calling SURFACE, and keyword *T3d* is used in the call to PLOTS.

```
SURFACE, FINDGEN(2, 2), /Nodata, /Save, $
   Xrange = [-1, 1], Yrange = [-1, 1], $
   Zrange = [0, 1]

z = FINDGEN(1000)/999
x = z * SIN(50 * z)
y = z * COS(50 * z)

PLOTS, x, y, z, /T3d
```

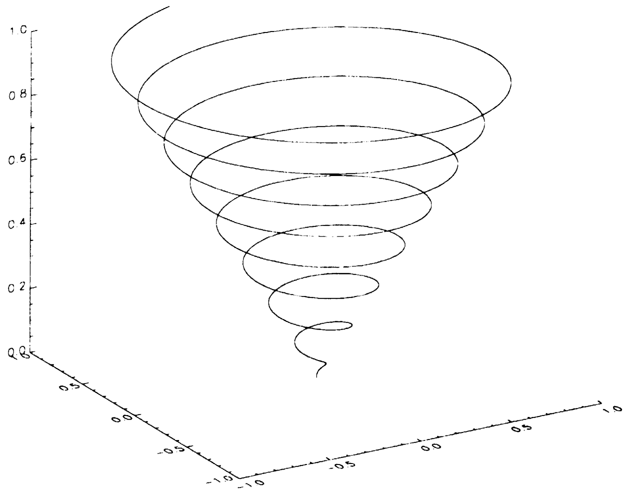


Figure 2-35 Line plot in $\mathbb{R}^3$.

See Also

PLOT, OPLOT

For additional examples, see *Getting Input from the Cursor* on page 90 of the *PV‑WAVE User's Guide* and *Procedure Used to Draw a House* on page 122 of the *PV‑WAVE User's Guide.*

PM Procedure

Performs formatted output of matrices to the standard output stream (logical file unit –1).

Usage

PM, $expr_1$, ..., $expr_n$

Input Parameters

expr$_i$ – Expression to be output.

Input Keywords

Title – If present, specifies a character string to be used as the title of the output matrix. Only one title is printed, regardless of the number of expressions sent to PM.

Format – If not specified, PV‑WAVE uses its default rules for formatting the output. Keyword *Format* allows the format to be specified in precise detail, using FORTRAN-style specifications.

Description

Procedure PM formats output to the standard output stream of matrices stored in the PV‑WAVE linear algebra matrix-storage mode. This procedure is designed to be used when working with matrices read by the procedures RM or RMF or other matrices using the PV‑WAVE matrix-storage scheme.

By using keywords, the form of the output matrix can be customized. Keyword *Title* can be used to specify a character string to be used as a title. Keyword *Format* is provided to allow for explicitly formatted output.

Example

In this example, a 2×3 matrix is read using the matrix-reading procedure RM and the results are printed using the matrix-printing procedure PM.

```
RM, a, 2, 3
```

Read in a 2×3 matrix.

```
row 0: 11 22 33
row 1: 40 50 60
```

```
PM, a
```

Output the matrix to standard output.

```
11.0000        22.0000        33.0000
40.0000        50.0000        60.0000
```

See Also

PMF, RM, RMF

See *Matrices* on page 93 of the *PV-WAVE Programmer's Guide* for more information.

PMF Procedure

Performs formatted output of matrices to a specified file unit.

Usage

PMF, *unit*, *expr*$_1$, ..., *expr*$_n$

Input Parameters

unit — File unit to which the output is sent.

expr$_i$ — Expression to be output.

Input Keywords

Title — Specifies a character string to be used as the title of the output matrix. Only one title is printed, regardless of the number of expressions sent to PMF.

Format — If not specified, PV-WAVE uses its default rules for formatting the output. Keyword *Format* allows the format to be specified in precise detail, using FORTRAN-style specifications.

Description

Procedure PMF formats output to a specified file unit of matrices stored in the PV-WAVE linear algebra matrix-storage mode. This procedure is designed to be used when working with matrices read by the procedures RM or RMF or other matrices using the PV-WAVE matrix-storage scheme.

Using keywords, the form of the output matrix can be customized. Keyword *Title* can be used to specify a character string to be used as a title. Keyword *Format* is provided to allow for explicitly formatted output.

Example

This example reads a 2 × 3 matrix using the matrix-reading procedure RM and prints the results to standard output, $(unit = -1)$, using the matrix-printing procedure PMF.

```
RM, a, 2, 3
```

Read matrix.

```
row 0: 11 22 33
row 1: 40 50 60
```

```
PMF, -1, a
```

Output the matrix to standard output.

```
    11.0000      22.0000      33.0000
    40.0000      50.0000      60.0000
```

See Also

PM, RM, RMF

See *Matrices* on page 93 of the *PV-WAVE Programmer's Guide* for more information.

POINT_LUN Procedure

Allows the current position of the specified file to be set to any arbitrary point in the file.

Usage

POINT_LUN, *unit, position*

Input Parameters

unit – The PV-WAVE file unit (logical unit number) for which the file position will be set.

position – A positive integer specifying the position of the file pointer as a byte offset from the start of the file.

Keywords

None.

Discussion

POINT_LUN is for the PV-WAVE programmer who wants explicit control over positioning for reading or writing within a given file. It is seldom used for general file I/O operations.

Example

In this example, POINT_LUN is used to move about within an unformatted file of integers.

```
a = INDGEN(100)
```

Create an integer vector of length 100 that is initialized to the values of its one-dimensional subscripts.

```
OPENW, unit, 'ptlun.dat', /Get_Lun
```

Open a file called ptlun.dat for writing.

```
WRITEU, unit, a
```

Write the 100-element integer vector as unformatted binary data to the file ptlun.dat.

```
POINT_LUN, -unit, pos
PRINT, 'Current offset into ptlun.dat is', $
   pos, ' bytes.'
```

Retrieve and display the current position within ptlun.dat.

```
Current offset into ptlun.dat is 200 bytes.
```

```
POINT_LUN, unit, 0
```

Rewind the file to the beginning.

```
b = INTARR(2)
```

Read two integers from the beginning of the file into a two-element integer array, b.

```
READU, unit, b
PRINT, b
0       1
```

```
POINT_LUN, -unit, pos
```

Since two integers were just read, each of length 2 bytes, the current position within the file should be 4 bytes offset from beginning. Retrieve current position.

```
PRINT, 'Current offset into ptlun.dat is', $
   pos, ' bytes.'
```

```
Current offset into ptlun.dat is 4 bytes.
```

```
FREE_LUN, unit
```

Close the file and free file unit number.

See Also

FREE_LUN, GET_LUN, OPENR, OPENU, OPENW, READ, WRITEU, FSTAT

For more information, see *Positioning File Pointers* on page 219 of the *PV-WAVE Programmer's Guide.*

POLY Function

Standard Library function that evaluates a polynomial function of a variable.

Usage

result = POLY(*x*, *coefficients*)

Input Parameters

x — The variable that is evaluated. May be a scalar or array.

coefficients — A vector containing one more element than the degree of the polynomial function. These elements are the coefficients of the polynomial equation that is used by POLY.

Returned Value

result — The values calculated from the polynomial function of *x*.

Keywords

None.

Discussion

POLY evaluates a polynomial function of a variable according to the formula:

$$result = c_0 + c_1x + c_2x^2 + \dots + c_{n-1}x^{n-1}$$

where n is the dimension of c, and c_0 through c_{n-1} are the *coefficients.*

POLY returns a variable with the same dimensions as x.
Each element of the result is equal to the computed value of $c_0 + c_1x + c_2x^2 + c_ix^i$ for each element of x.

The POLY function can be used in conjunction with POLY_FIT and POLYFITW, which both return the coefficients of a polynomial function fitted through data.

Example

```
x = 2
c = [1,2, 3]
func = POLY(x, c)
PRINT, func
   17
```

See Also

POLY_FIT, POLYFITW, POLY_2D

POLY_AREA Function

Standard Library function that returns the area of an *n*-sided polygon, given the vertices of the polygon.

Usage

result = POLY_AREA(*x*, *y*)

Input Parameters

x — An *n*-element real vector containing the X coordinates of each vertex in the polygon.

y — An *n*-element real vector containing the Y coordinates of each vertex in the polygon.

Returned Value

result — The area of the polygon, returned as a floating-point value.

Keywords

None.

Discussion

POLY_AREA assumes that the input polygon has *n* vertices with *n* sides, and that the edges connect the vertices in the order $[(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n), (x_1, y_1)]$. The last vertex must be connected to the first.

Examples

```
x = [1, 3, 2]
y = [1, 1, 4]
area = POLY_AREA(x, y)
PRINT, area
   3.00000

x = [2, 4, 4, 2]
y = [1, 1, 2, 2]
PRINT, POLY_AREA(x, y)
   2.00000
```

See Also

POLYCONTOUR, POLYFILL, POLYFILLV, POLYSHADE

POLY_C_CONV Function

Returns a list of colors for each polygon, given a polygon list and a list of colors for each vertex.

Usage

result = POLY_C_CONV(*polygon_list, colors*)

Input Parameters

polygon_list — An array containing a list of polygons. For more information, see *Vertex Lists and Polygon Lists* on page 187 of the *PV-WAVE User's Guide.*

colors — A vertex-based color list.

Returned Value

result — An integer vector containing the list of colors, one color for each input polygon. (In other words, the result contains the same number of colors as the number of polygons in *polygon_list.*)

Keywords

None.

Discussion

POLY_C_CONV is useful for converting a vertex-based color list to a polygon-based list. For example, the SHADE_VOLUME procedure returns a list of polygon colors when the *Shades* keyword is used. This list has one color per vertex. The POLY_PLOT procedure, however, requires a color list with one color per polygon.

Examples

```
PRO sphere_demo2
```

This program displays data warped onto an irregular sphere.

```
radii = RANDOMU(s, 60, 60)
radii = SMOOTH((radii + 1.0), 2)
POLY_SPHERE, radii, 60, 60, vertex_list, $
   polygon_list
```

Define the sphere as a list of polygons.

```
p_colors = BYTSCL(DIST(60), Top=127)
```

Define the shading colors for the sphere.

```
WINDOW, 0, Colors=128, XPos=16, YPos=384
LOADCT, 1
CENTER_VIEW, Xr=[-2.0, 2.0], $
   Yr=[-2.0, 2.0], Zr=[-2.0, 2.0], $
   Ax=(-75.0), Az=(-90.0), Zoom=0.99
```

Set up the viewing window and load the color table.

```
TV, POLYSHADE(vertex_list, polygon_list, $
   /T3d, Shade=p_colors)
```

Construct a shaded surface representation of the data and display it using POLYSHADE.

```
WINDOW, 1, Colors=128, XPos=256, YPos=64
```

Create a new window to plot in.

```
pg_num = POLY_COUNT(polygon_list)
```

Count the number of polygons in the sphere.

```
vertex_list = POLY_NORM(vertex_list)
vertex_list = POLY_TRANS(vertex_list, !P.T)
vertex_list = POLY_DEV(vertex_list, 640, 512)
```

Transform the polygon vertices from data coordinates to device coordinates.

```
p_colors = POLY_C_CONV(polygon_list, $
   p_colors(*))
```

Convert the colors from a vertex-based list to a polygon-based list.

```
POLY_PLOT, vertex_list, polygon_list, $
   pg_num, 640, 512, p_colors, 0, -1
```

Plot the sphere using POLY_PLOT.

```
END
```

For another example, see the `poly_demo1` demonstration program in `$WAVE_DIR/demo/arl`.

See Also

POLY_PLOT

For details on the POLYSHADE and SHADE_VOLUME routines, see their descriptions in the *PV-WAVE Reference*.

POLY_2D Function

Performs polynomial warping of images.

Usage

result = POLY_2D(*array*, $coeff_x$, $coeff_y$ [, *interp* [, dim_x ,..., dim_y]])

Input Parameters

array – The array to be processed. Must be two-dimensional. Can be of any basic type except string.

$\boldsymbol{coeff_x}$ – The X coefficients (see Discussion below).

$\boldsymbol{coeff_y}$ – The Y coefficients (see Discussion below).

interp – If present and nonzero, specifies that the bilinear interpolation method is to be used in the resampling. Otherwise, the nearest neighbor method is used.

$\boldsymbol{dim_x}$ – If present, specifies the number of columns in the resulting array. Otherwise, the output has the same number of columns as *array*.

$\boldsymbol{dim_y}$ – If present, specifies the number of rows in the resulting array. Otherwise, the output has the same number of rows as *array*.

Returned Value

result — A two-dimensional array containing the warped image. It is of the same data type as *array*.

Output Keywords

Missing — Specifies the output value for points whose x', y' is outside the bounds of *array*. (If this keyword is not used, these values are extrapolated from the nearest pixel of *array*.)

Discussion

POLY_2D performs a geometrical transformation in which the resulting array is defined by:

$$g(x,y) = f(x', y') = f[a(x,y), b(x,y)]$$

where $g(x,y)$ represents the pixel in the output image at coordinate (x,y), and $f(x', y')$ is the pixel at (x', y') in the input image that is used to derive $g(x,y)$.

The functions $a(x,y)$ and $b(x,y)$ are polynomials in x and y of degree n, and specify the spatial transformation:

$$x' = a(x,y) = \sum_{i=0}^{n}\sum_{j=0}^{n} coeff_{x_{i,j}} x^j y^i$$

$$y' = b(x,y) = \sum_{i=0}^{n}\sum_{j=0}^{n} coeff_{y_{i,j}} x^j y^i$$

where n is the degree of the polynomials that are being used to produce the warping, and $coeff_x$ and $coeff_y$ are arrays containing the polynomial coefficient. Each array must contain $(n + 1)^2$ elements.

For example, for a linear transformation, $coeff_x$ and $coeff_y$ must contain four elements and may be either a 2-by-2 array or a 4-element vector. $Cx_{i,j}$ contains the coefficient used to determine x', and is the weight of the term $x^j y^i$.

The nearest neighbor interpolation method is not linear, because new values that are needed are merely set equal to the nearest existing value of *image*. For more information on bilinear interpolation, see the BILINEAR function.

Note Bilinear interpolation can be time-consuming. For example, it requires about twice as much time as does the nearest neighbor method, even if you are working with a linear case (in other words, if n equals 1).

Tip The POLYWARP function may be used to fit (x', y') as a function of (x, y) and return the coefficient arrays C_x and C_y .

Example

Some simple linear (degree one) transformations are shown below:

$P_{0,0}$	$P_{1,0}$	$P_{0,1}$	$P_{1,1}$	$Q_{0,0}$	$Q_{1,0}$	$Q_{0,1}$	$Q_{1,1}$	Effect
0	0	1	0	0	1	0	0	Identity
0	0	0.5	0	0	1	0	0	Stretch X by a factor of 2
0	0	1	0	0	2.0	0	0	Shrink Y by a factor of 2
z	0	0	0	0	0	0	0	Shift left by z pixels
0	1	0	0	0	0	1	0	Transpose

See Also

BILINEAR, POLY, POLY_FIT, POLYWARP

For details on interpolation methods. see *Efficiency and Accuracy of Interpolation* on page 170 of the *PV-WAVE User's Guide.*

POLYCONTOUR Procedure

Standard Library procedure that shades enclosed contours with specified colors.

Usage

POLYCONTOUR, *filename*

Input Parameters

filename – The name of the file containing the contour paths. This file must have been created with a CONTOUR call using the *Path_Filename* keyword.

Input Keywords

Color_Index – If present, must be set to an array containing the color indices to be used in the plot. Element *i* of this array contains the color of contour level number *i* – 1. Element 0 contains the background color. There must be one more color index than there are number of contour levels.

If not present, then *Color_Index* equals INDGEN(25) + 1.

Delete_File – If present and nonzero, deletes *filename* after POLYCONTOUR has finished processing.

Pattern – A three-dimensional array containing the patterns used to fill the various contour levels. Each pattern must be an *n*-by-*m* rectangular array of pixels of any size. (See the description of the *Pattern* graphics keyword in Chapter 3, *Graphics and Plotting Keywords*, for an example.)

If there are *NP* number of patterns specified, then *Pattern* will be dimensioned (*n, m, NP*). The patterns will be used in order to fill the various contour levels. If there are more levels than patterns, the patterns will be cyclically repeated.

Discussion

POLYCONTOUR creates a contour plot with the area in between the contour lines filled with a solid color or a user-defined pattern. It uses the POLYFILL procedure with normalized coordinates to fill the contours on the display.

All contours must be closed before calling POLYCONTOUR, as it does not draw open contours. If not, an error message is printed and the procedure stops.

Tip To eliminate open contours, surround the original array with a one-element border on all sides. These border elements must have a value smaller than or equal to the minimum data array value. The following code fragment demonstrates this tip:

```
new_a = REPLICATE(MIN(a), n+2, m+2)
```
Make the background.

```
new_a(1, 1) = a
```
Insert original data.

```
CONTOUR, new_a, Path='filename'
```
Create contour path file.

```
POLYCONTOUR, 'filename'
```
Fill contours with default colors.

Example

This example creates a contour plot of the PV-WAVE Pike's Peak elevation demo file, with the area in between the contour lines filled with a solid color.

```
OPENR, 1, !Data_dir + 'pikeselev.dat'
pikes = FLTARR(60, 40)
READF, 1, pikes
```
Read in the data file.

```
c_pikes = FLTARR(62, 42)
c_pikes(1, 1) = pikes
```
Close any open contours.

```
TEK_COLOR
```
Load a color table.

```
CONTOUR, c_pikes, $
 Levels=[5,6,7,8,9,10,11,12,13,14,15]*1000, $
 Path='path.dat', XStyle=1, YStyle=1
```
Contour the data and store the results in file path.dat.

```
POLYCONTOUR, 'path.dat'
```
Display the contour plot with contours filled with solid colors.

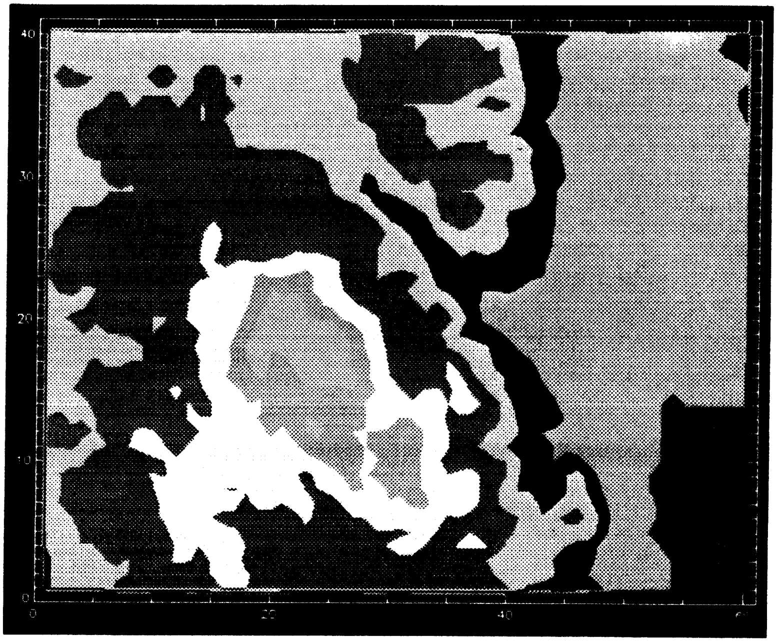


Figure 2-36 Contour plot filled with solid colors.

The following commands fill in the area in between the contour lines with a user-defined pattern.

```
pat1 = BYTARR(3, 3)
pat1(1, *) = 255
pat1(*, 1) = 255
```
Create the first pattern, a cross pattern.

```
pat2 = BYTARR(3, 3)
FOR i = 0, 2 DO pat2(i, i) = 255
```

Create the second pattern, a diagonal pattern.

```
pat3 = BYTARR(3, 3)
```

Create the third pattern, a solid fill of color zero.

```
pat4 = REPLICATE(255b, 3, 3)
```

Create the fourth pattern, a solid fill of color 255.

```
pat5 = BYTARR(3, 3)
FOR i = 0, 2 DO pat5(2-i, i) = 255
```

Create the fifth pattern, a backwards diagonal pattern.

```
pat3d = BYTARR(3, 3, 5)
```

Create a 3D array in which to store the patterns.

```
pat3d(*, *, 0) = pat1
pat3d(*, *, 1) = pat2
pat3d(*, *, 2) = pat3
pat3d(*, *, 3) = pat4
pat3d(*, *, 4) = pat5
```

Store the patterns in the array named pat3d.

```
POLYCONTOUR, 'path.dat', Pattern=pat3d, $
   /Delete_file
```

Display the contour plot with the contours lines filled with the pattern.

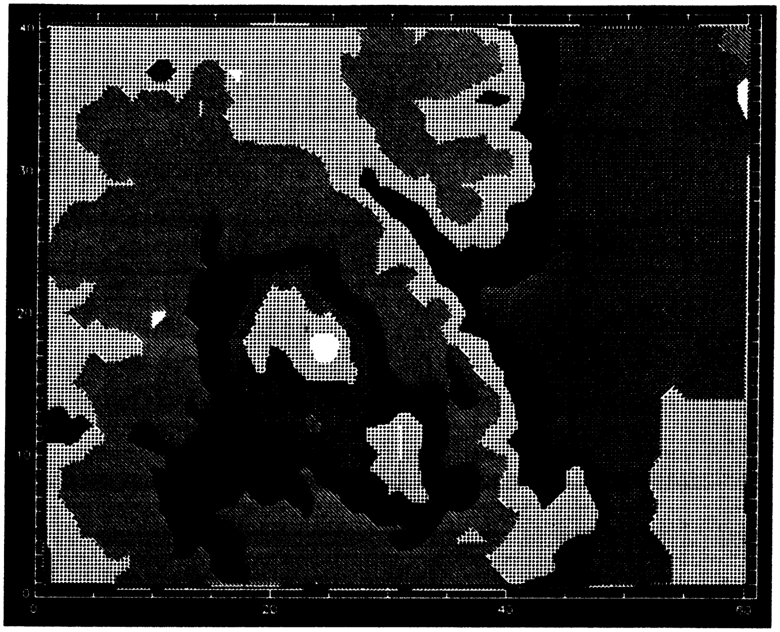


Figure 2-37 Pattern-filled contours.

Tip Instead of using POLYCONTOUR to create color-filled contour plots, a similar result can be achieved by loading a color table with the TEK_COLOR procedure and then using a command of the form `TV, BYTSCL(array, Top=n)` where *n* + *1* equals the number of contour levels to be colored.

In other words, the above example could be displayed using the commands:

```
TEK_COLOR
pikes=REBIN(pikes, 600, 400)
TV, BYTSCL(pikes, Top=10)
```

Here are some of the advantages to using this technique, rather than the POLYCONTOUR procedure, to create color-filled contour plots:

- You have easy access to the image processing routines that let you quickly analyze your data (these routines include DEFROI, HISTOGRAM, and PROFILES).
- You don't have to worry about open contours.
- You don't have to create a temporary file in your directory.

See Also

CONTOUR, POLYFILL, TEK_COLOR

POLY_C_CONV Function

Returns a list of colors for each polygon, given a polygon list and a list of colors for each vertex.

Usage

result = POLY_C_CONV(*polygon_list, colors*)

Input Parameters

polygon_list — An array containing a list of polygons. For more information, see *Vertex Lists and Polygon Lists* on page 187 of the *PV-WAVE User's Guide.*

colors — A vertex-based color list.

Returned Value

result — An integer vector containing the list of colors, one color for each input polygon. (In other words, the result contains the same number of colors as the number of polygons in *polygon_list.*)

Keywords

None.

Discussion

POLY_C_CONV is useful for converting a vertex-based color list to a polygon-based list. For example, the SHADE_VOLUME procedure returns a list of polygon colors when the *Shades* keyword is used. This list has one color per vertex. The POLY_PLOT procedure, however, requires a color list with one color per polygon.

Examples

```
PRO sphere_demo2
```

This program displays data warped onto an irregular sphere.

```
radii = RANDOMU(s, 60, 60)
radii = SMOOTH((radii + 1.0), 2)
POLY_SPHERE, radii, 60, 60, vertex_list, $
   polygon_list
```

Define the sphere as a list of polygons.

```
p_colors = BYTSCL(DIST(60), Top=127)
```

Define the shading colors for the sphere.

```
WINDOW, 0, Colors=128, XPos=16, YPos=384
LOADCT, 1
CENTER_VIEW, Xr=[-2.0, 2.0], $
   Yr=[-2.0, 2.0], Zr=[-2.0, 2.0], $
   Ax=(-75.0), Az=(-90.0), Zoom=0.99
```

Set up the viewing window and load the color table.

```
TV, POLYSHADE(vertex_list, polygon_list, $
   /T3d, Shade=p_colors)
```

Construct a shaded surface representation of the data and display it using POLYSHADE.

```
WINDOW, 1, Colors=128, XPos=256, YPos=64
```

Create a new window to plot in.

```
pg_num = POLY_COUNT(polygon_list)
```

Count the number of polygons in the sphere.

```
vertex_list = POLY_NORM(vertex_list)
vertex_list = POLY_TRANS(vertex_list, !P.T)
vertex_list = POLY_DEV(vertex_list, 640, 512)
```

Transform the polygon vertices from data coordinates to device coordinates.

```
p_colors = POLY_C_CONV(polygon_list, $
   p_colors(*))
```

Convert the colors from a vertex-based list to a polygon-based list.

```
POLY_PLOT, vertex_list, polygon_list, $
    pg_num, 640, 512, p_colors, 0, -1
```

Plot the sphere using POLY_PLOT.

```
END
```

For another example, see the `poly_demo1` demonstration program in `$WAVE_DIR/demo/arl`.

See Also

POLY_PLOT

For details on the POLYSHADE and SHADE_VOLUME routines, see their descriptions in the *PV-WAVE Reference*.

POLY_COUNT Function

Returns the total number of polygons contained in a polygon list.

Usage

result = POLY_COUNT(*polygon_list*)

Input Parameters

polygon_list — An array containing a list of polygons. For more information, see *Vertex Lists and Polygon Lists* on page 187 of the *PV-WAVE User's Guide*.

Returned Value

result — The total number of polygons contained in the specified polygon list.

Keywords

None.

Discussion

The value returned by POLY_COUNT is suitable for input as the *pg_num* parameter used in the POLY_PLOT procedure.

Examples

See the Examples section in the description of the POLY_C_CONV routine.

For another example, see the `sphere_demo3` demonstration program in `$WAVE_DIR/demo/arl`.

See Also

POLY_PLOT

POLY_DEV Function

Returns a list of 3D points converted from normal coordinates to device coordinates.

Usage

result = POLY_DEV(*points, winx, winy*)

Input Parameters

points – A (3, *n*) array of points (or vertices) to transform.

winx, winy – The maximum X and Y dimension, respectively, in device coordinates. Usually, this is set to the X and Y size of the current PV-WAVE window.

Returned Value

result – The list of 3D points that has been converted from normal coordinates to device coordinates. The list is in long integer format.

Keywords

None.

Examples

```
PRO poly_demo1
```

This program displays a perspective view of a surface from a viewpoint within the data.

```
winx = 1000
winy = 750
```

Specify the window size.

```
imgx = 477
imgy = 512
```

Specify the image size.

```
elev_dat = BYTARR(imgx, imgy)
OPENR, 1, !Data_Dir + 'bldr_elev.dat'
READU, 1, elev_dat
CLOSE, 1
```

Read in the elevation image data.

```
landsat = BYTARR(imgx, imgy)
OPENR, 1, !Data_Dir + 'bldr_img7.dat'
READU, 1, landsat
CLOSE, 1
```

Read in the Landsat image data.

```
imgx = 120
imgy = 125
elev_dat = CONGRID(FLOAT(elev_dat), imgx, $
   imgy, /Interp)
```

Shrink the elevation data to a 120-by-125 array.

```
landsat = BYTSCL(CONGRID(FLOAT(landsat), $
   imgx, imgy, /Interp), Top=127)
```

Shrink the Landsat image to a 120-by-125 array and scale the image into the range of 0 – 127.

```
zscale = 0.08
```

Define the Z compression factor.

```
viewpoint = [105.0, 70.0, (5.0 * zscale)]
viewvector = [-10.0, -2.5, -0.75]
perspective = 0.06
```

```
izoom = 11.0
viewup = [0.0, 1.0]
viewcenter = [0.5, 0.5]
xr = [0, (imgx - 1)]
yr = [0, (imgy - 1)]
zr = [MIN(elev_dat), MAX(elev_dat)]
```

Define the view parameters.

```
elev_dat = elev_dat * zscale
```

Compress the elevation data.

```
SET_VIEW3D, viewpoint, viewvector, $
   perspective, izoom, viewup, $
   viewcenter, winx, winy, xr, yr, zr
```

Set up a 3D view based on eye-point and view vector.

```
PRINT, "Building polygons ..."
POLY_SURF, elev_dat, vertex_list, $
   polygon_list, pg_num
```

Generate the polygons representing the surface.

```
vertex_list = vertex_list
PRINT, "Normalizing coordinates ..."
vertex_list = POLY_NORM(vertex_list)
```

Convert the polygon vertices from data coordinates to normal coordinates.

```
PRINT, "Transforming coordinates ..."
vertex_list = POLY_TRANS(vertex_list, !P.T)
```

Transform the new coordinates.

```
PRINT, "Changing to device coordinates ..."
vertex_list = POLY_DEV(vertex_list, winx, $
   winy)
```

Convert the normal coordinates to device coordinates.

```
WINDOW, XSize=winx, YSize=winy, XPos=10, $
   YPos=50, Colors=128
```

Set up a new window for plotting.

```
PRINT, "Plotting ..."
```

```
landsat = POLY_C_CONV(polygon_list, landsat)
```

Create an array containing one color for each polygon.

```
POLY_PLOT, vertex_list, polygon_list, $
   pg_num, winx, winy, landsat, -1, -1
```

Plot the surface.

```
END
```

For other examples, see the following demonstration programs in `$WAVE_DIR/demo/arl`: `sphere_demo2`, `sphere_demo3`, and `vol_demo4`.

See Also

POLY_NORM, POLY_TRANS

For more information, see *Coordinate Conversion* on page 193 of the *PV-WAVE User's Guide* and *Three Graphics Coordinate Systems* on page 59 of the *PV-WAVE User's Guide.*

POLYFILL Procedure

Fills the interior of a region of the display enclosed by an arbitrary 2D or 3D polygon.

Usage

POLYFILL, *x* [, *y* [, *z*]]

Input Parameters

x — A vector parameter providing the X coordinates of the points to be connected.

If only one parameter is specified, *x* must be an array of either two or three vectors: `(2,*)` or `(3,*)`. In this special case, `x(0,*)` is taken as the X values, `x(1,*)` is taken as the Y values, and `x(2,*)` is taken as the Z values.

y — A vector parameter providing the Y coordinates of the points to be connected.

z — If present, a vector parameter providing the Z coordinates of the points to be connected. If *z* is not present, *x* and *y* are used to draw lines in two dimensions. *z* has no effect if the keyword *T3D* is not specified and the system variable !P.T3d = 0.

Keywords

POLYFILL keywords are listed below. For a description of each keyword, see Chapter 3, *Graphics and Plotting Keywords.*

Channel	Fill_Pattern	Pattern	T3d
Clip	Linestyle	Psym	Thick
Color	Line_Fill	Spacing	
Data	Noclip	Symsize	
Device	Normal		

Z-buffer Specific Keywords

These keywords allow you to warp images over 2D or 3D polygons; the keywords are valid only when the Z-buffer device is active. For more information on the Z-buffer, see *Z-buffer Output* on page 99 of the *PV-WAVE User's Guide.*

Image_Coordinates — To warp an image over a polygon, pass the image into POLYFILL with the *Pattern* keyword, and specify a (2, *n*) array containing the image space coordinates that correspond to each of the *n* vertices with the *Image_Coordinates* keyword.

Image_Interpolate — When present and nonzero, specifies that bilinear interpolation is used instead of the nearest-neighbor method of sampling.

Mip — When present and nonzero, produces improved transparency by Maximum Intensity Projection. Rather than setting an arbitrary threshold value, a pixel is set in the Z-buffer, regardless of its depth, if its intensity is greater than the current pixel in the buffer.

Threshold — Pixels less than the *Threshold* value are not drawn, producing a transparent effect.

Discussion

The polygon is defined by a list of connected vertices stored in *x*, *y*, and *z*. The coordinates can be given in data, device, or normalized form using the *Data, Device*, or *Normal* keywords.

POLYFILL uses various filling methods:

- solid fill
- parallel lines
- a pattern contained in an array
- hardware-dependent fill pattern

Solid Fill Method – Most devices can fill with a solid color. Solid fill is performed using the line fill method for devices that don't have this hardware capability. Keywords that specify a method are not required for solid filling.

Line Fill Method – Filling using parallel lines is device independent and works on all devices that can draw lines. Cross-hatching may be obtained with multiple fillings of differing orientations. The spacing, linestyle, orientation, and thickness of the filling lines may be specified using the corresponding keywords. The *Line_Fill* keyword selects this filling style, but is not required if either the *Orientation* or *Spacing* keywords are present.

Patterned Fill Method – The method of patterned filling and the usage of various fill patterns is hardware dependent. The fill pattern array may be directly specified with the *Pattern* keyword for some output devices. If this keyword is omitted, the polygon is filled with the hardware-dependent pattern index specified by the *Fill_Pattern* keyword.

Example 1

In this example, POLYFILL is used to create and fill a square, triangle, and pentagon with different patterns. Device coordinates are used for these polygons.

```
a = INTARR(10, 10)
```

Create fill pattern for square. This will be an X pattern.

```
FOR i = 0, 9  DO a(i, i) = !D.N_Colors - 1
a = a + ROTATE(a, 1)
```

```
POLYFILL, [225, 375, 375, 225], $
   [275, 275, 425, 425], /Device, Pattern = a
```

Create square and fill it with the pattern in a.

```
b = INTARR(10, 10)
```

Create fill pattern (horizontal lines) for triangle.

```
b(*, 2) = !D.N_Colors - 1
b(*, 7) = !D.N_Colors - 1
```

```
POLYFILL, [40, 180, 110], [50, 50, 200], $
   /Device, Pattern = b
```

Create triangle and fill it with the pattern in b.

```
c = INTARR(10, 10)
```

Create fill pattern (vertical lines) for pentagon.

```
c(2, *) = !D.N_Colors - 1
c(7, *) = !D.N_Colors - 1
```

```
POLYFILL, [420, 560, 560, 490, 420], $
   [50, 50, 130, 200, 130], /Device, $
   Pattern = c
```

Create pentagon and fill it with the pattern in c.

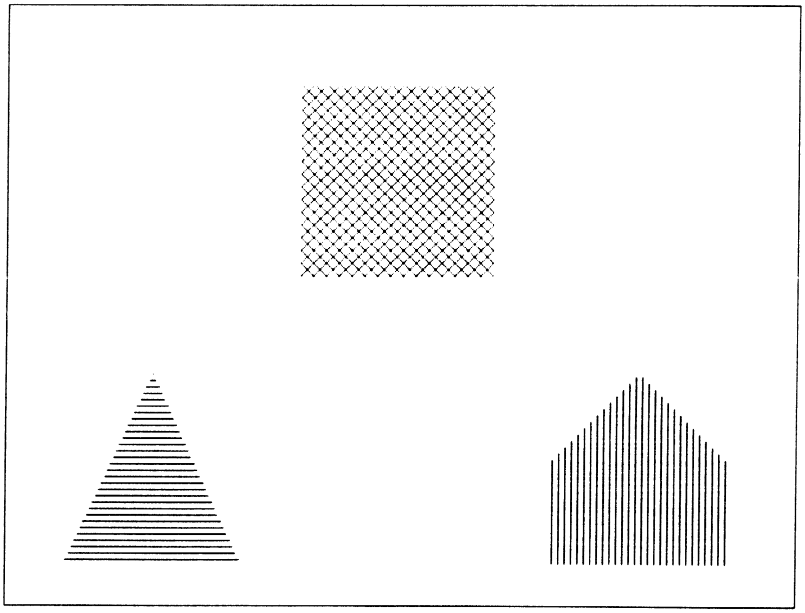


Figure 2-38 Pattern-filled polygons.

Example 2

This example uses POLYFILL to draw the faces of cubes that are stacked on top of each other in pyramid fashion. The width and length of the base of the stack is equal to *numcubes*. This value is an argument passed to the procedure that draws the cubes.

The SURFACE procedure is used to establish a three-dimensional transformation matrix that determines the view. The *T3d* keyword is used with POLYFILL so that the transformation matrix established by SURFACE is used.

```
PRO cubes, numcubes
```

Argument numcubes is the number of cubes to place along the base.

```
COMMON com1, size, colr1, colr2, colr3
```

```
size = 1.0D/numcubes
```

Determine size, which is the width, height, and length of each cube. Note that everything is normalized to lie between 0 and 1.

```
LOADCT, 3
```

Load red temperature color table.

```
SURFACE, FLTARR(2, 2), /Nodata, Xstyle = 4, $
   Ystyle = 4, Zstyle = 4, Xrange = [0, 1], $
   Yrange = [-1, 0], Zrange = [0, 1], /Save
```

Establish three-dimensional transformation using SURFACE. The Nodata keyword permits the use of a dummy two-dimensional array to be passed to SURFACE. Setting Xstyle, Ystyle, and Zstyle to 4 causes the axes to be invisible. The ranges are set here, and the transformation is saved.

```
colr1 = FIX(!D.N_Colors/2.0)
colr2 = (FIX((!D.N_Colors - colr1)/2.0) + $
   colr1) MOD !D.N_Colors
colr3 = (FIX((!D.N_Colors - colr2)/2.0) + $
   colr1) MOD !D.N_Colors
```

Determine available colors to use.

```
z = 0
```

```
FOR i = FIX(numcubes), 1, -1 DO BEGIN
   x = (FIX(numcubes) - i) * size
   y = -size
   z = z + size
```
Draw the cubes by layer, starting at the bottom.

```
   FOR j = 1, i - 1 DO BEGIN
      draw_cube, x, y, z
```
Draw the cubes along the left edge of the current layer.

```
      y = y - size
   ENDFOR

   x = (i - 1) * size + x

   FOR j = 1, i DO BEGIN
      DRAW_CUBE, x, y, z
      x = x - size
```
Draw the cubes along the right edge of the current layer.

```
   ENDFOR

ENDFOR
END

PRO draw_cube, x, y, z
```
Draw a cube.

```
COMMON com1, size, colr1, colr2, colr3
left_face, x, y, z, colr1
right_face, x, y, z, colr2
top_face, x, y, z, colr3
END

PRO left_face, x, y, z, colr
COMMON com1, size
POLYFILL, [x, x, x, x], [y, y, y + size, $
   y + size], [z, z - size, z - size, z], $
   /T3d, Color = colr
```
Use POLYFILL to draw the left face of a cube.

```
END
```

```
PRO right_face, x, y, z, colr
COMMON com1, size
POLYFILL, [x, x + size, x + size, x], $
   [y, y, y, y], [z, z, z - size, z - size], $
   /T3d, Color = colr
```

Use POLYFILL to draw the right face of a cube.

```
END

PRO top_face, x, y, z, colr
COMMON com1, size
POLYFILL, [x, x + size, x + size, x], $
   [y, y, y + size, y + size], [z, z, z, z], $
   /T3d, Color = colr
```

Use POLYFILL to draw the top face of a cube.

```
END
```

If this procedure is contained in a file named `cubes.pro` in your directory, it can be compiled with the following command:

```
.RUN cubes
```

The number of levels in the pyramid height is equal to the number passed to *cubes*. If the procedure is run with the command:

```
cubes, 8
```

then a pyramid with eight levels is created, as shown below.

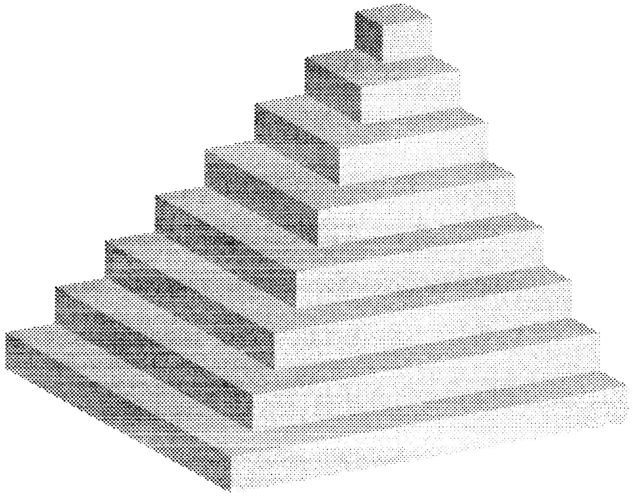


Figure 2-39 Example of three-dimensional polygon filling.

See Also

POLY_AREA, POLYCONTOUR

POLYFILLV Function

Returns a vector containing the subscripts of the array elements contained inside a specified polygon.

Usage

result = POLYFILLV(*x, y, sx, sy* [, *run_length*])

Input Parameters

x – A vector containing the X subscripts of the vertices that define the polygon.

y – A vector containing the Y subscripts of the vertices that define the polygon.

sx – The number of columns in the array surrounding the polygon.

sy – The number of rows in the array surrounding the polygon.

run_length – If present and nonzero, returns a vector of run lengths, rather than subscripts. Each element with an even subscript result contains the length of the run, and the following element contains the starting index of the run.

For large polygons, using *run_length* can save considerable space.

Returned Value

result – A vector containing the subscripts of the array elements contained inside a polygon defined by *x* and y.

Keywords

None.

Discussion

POLYFILLV is useful in defining, analyzing, and displaying regions of interest within a two-dimensional array.

The *x* and *y* parameters are vectors containing the subscripts of the vertices that define the polygon in the coordinate system of the two-dimensional *sx*-by-*sy* array.

The *sx* and *sy* parameters define the number of columns and rows in the array enclosing the polygon. At least three points must be specified, and all points should lie within the limits:

$$0 \le x_i < sx \quad \text{and} \quad 0 \le y_i < sy \quad \text{for all } i$$

The polygon is defined by connecting each point with its successor and the last point with the first.

Example

This example determines the mean and standard deviation of the elements within a triangular region defined by the vertices at pixel coordinates (100,100), (200,300), and (300,100), inside a 512-by-512 array called `data`.

```
x = [100, 200, 300]
y = [100, 300, 100]
```

Define triangle's coordinates.

```
p = data(POLYFILLV(x, y, 512, 512))
```

Get the subscripts of the elements in the polygon.

```
std = STDEV(p, mean)
```

Use the STDEV function to obtain the mean and standard deviation of the selected elements.

See Also

POLY_AREA

POLY_FIT Function

Standard Library function that fits an *n*-degree polynomial curve through a set of data points using the least-squares method.

Usage

result = POLY_FIT(*x*, *y*, *deg* [, *yft*, *ybd*, *sig*, *mat*])

Input Parameters

x – The vector containing the X (independent) coordinates of the data.

y – The vector containing the Y (dependent) coordinates of the data. Must have the same number of elements as *x*.

deg – The degree of the polynomial to be fitted to the data.

Output Parameters

yft – The vector containing the calculated Y values.

ybd – The vector containing the error estimate of each point. (The error estimate is equal to one standard deviation.)

sig – The standard deviation of the function, expressed in the units of the Y direction.

mat – The correlation matrix of the coefficients.

Returned Value

result – The vector containing the coefficients of the polynomial equation which best approximates the data.

Keywords

None.

Discussion

POLY_FIT uses a least-squares method for determining the equation of the curve, which minimizes the error at each point of the curve. This function is useful for showing the relationship between two variables.

POLY_FIT returns a vector with a length of *deg* + 1. For example, if you had requested a polynomial of degree 3, the fitted curve would have the equation:

$$f(x) = result(3)x^3 + result(2)x^2 + result(1)x + result(0)$$

The *yft* parameter is in a format that can be readily displayed as a curve alongside the input curve, thereby allowing you to compare the two curves.

Example

```
x = FINDGEN(9)
y = [5., 4., 3., 2., 2., 3., 5., 6., 7.]
```

Create the data.

```
TEK_COLOR
```

Load a color table.

```
PLOT, x, y, Title='POLY_FIT EXAMPLE'
```

Plot the data.

```
coeff_1_deg = POLY_FIT(x, y, 1, yfit)
```

Fit with a first-order polynomial.

```
OPLOT, x, yfit, Color=3
```

Overplot the calculated values on the original plot.

```
coeff_3_deg = POLY_FIT(x, y, 3, yfit)
```

Fit with a third-order polynomial.

```
OPLOT, x, yfit, Color=2
```

Overplot the calculated values on the original plot.

```
coeff_5_deg = POLY_FIT(x, y, 5, yfit)
```

Fit with a fifth-order polynomial.

```
OPLOT, x, yfit, Color=6
```

Overplot the calculated values on the original plot.

```
labels = ['Original data',$
   'Fit with first order polynomial',$
   'Fit with third order polynomial',$
   'Fit with fifth order polynomial']
```

```
LEGEND, labels, [255, 3, 2, 6], [0, 0, 0, 0],$
   [0, 0, 0, 0], 4., 1.5, .3
```

Put a legend on the plot.

See Also

CURVEFIT, FUNCT, GAUSSFIT, POLYFITW, REGRESS, SVDFIT

Additional curve fitting algorithms are available with PV-WAVE *Advantage.*

POLYFITW Function

Standard Library function that fits an *n*-degree polynomial curve through a set of data points using the least-squares method.

Usage

result = POLYFITW(*x, y, wt, deg* [, *yft, ybd, sig, mat*])

Input Parameters

x – The vector containing the X (independent) coordinates of the data.

y – The vector containing the Y (dependent) coordinates of the data. Must have the same number of elements as *x*.

wt – The vector of weighting factors for determining the weighting of the least-squares fit. Must have the same number of elements as *x*.

deg – The degree of the polynomial to be fitted to the data.

Output Parameters

yft – The vector containing the calculated Y values.

ybd – The vector containing the error estimate of each point. (The error estimate is equal to one standard deviation.)

sig – The standard deviation of the function, expressed in the units of the Y direction.

mat – The correlation matrix of the coefficients.

Returned Value

result – The vector containing the coefficients of the polynomial equation that best approximates the data. It has a length of *deg* + 1.

Keywords

None.

Discussion

POLYFITW is similar to the POLY_FIT function, except that it permits the weighting of data points. Weighting is useful when you want to correct for potential errors in the data you are fitting to a curve. The weighting factor, *wt*, adjusts the parameters of the curve so that the error at each point of the curve is minimized. For more information, see the section *Weighting Factor* on page 149.

Example

```
x = FINDGEN(9)
y = [5., 4., 3., 2., 2., 3., 5., 6., 7.]
```

Create the data.

```
TEK_COLOR
PLOT, x, y, Title='POLYFITW EXAMPLE'
```

Load a color table and plot the original data.

```
wt = FLTARR(9) + 1.0
coeff_no_wt = POLYFITW(x, y, wt, 1, yfit)
```

Fit with a first-order polynomial, without weighting.

```
OPLOT, x, yfit, Color=3
```

Overplot the calculated values on the original plot.

```
wt = 1.0/y
coeff_stat_wt = POLYFITW(x, y, wt, 1, yfit)
```

Fit with statistical weighting.

```
OPLOT, x, yfit, Color=2
```

Overplot the calculated values on the original plot.

```
labels=['Original data',$
   'Fit with no weighting',$
   'Fit with statistical weighting']
```

```
LEGEND, labels, [255, 3, 2], [0, 0, 0], $
   [0, 0, 0], 4., 1.5, .3
```

Put a legend on the plot.

See Also

CURVEFIT, FUNCT, GAUSSFIT, POLY_FIT, REGRESS SVDFIT

POLY_MERGE Procedure

Merges two vertex lists and two polygon lists together so that they can be rendered in a single pass.

Usage

POLY_MERGE, *vertex_list1, vertex_list2, polygon_list1, polygon_list2, vert, poly, pg_num*

Input Parameters

vertex_list1 – The first vertex list.

vertex_list2 – The second vertex list.

polygon_list1 – The first polygon list.

polygon_list2 – The second polygon list.

Note For more information, see *Vertex Lists and Polygon Lists* on page 187 of the *PV-WAVE User's Guide.*

Output Parameters

vert – A new variable consisting of *vertex_list1* and *vertex_list2* merged together.

poly – A new variable consisting of *polygon_list1* and *polygon_list2* merged together and modified so that it is compatible with *vert.*

pg_num – The total number of polygons in the merged list.

Input Keywords

Edge1 – A vector containing the edge colors for the first polygon list.

Edge2 – A vector containing the edge colors for the second polygon list.

Fill1 – A vector containing the fill colors for the first polygon list.

Fill2 – A vector containing the fill colors for the second polygon list.

Opaque1 – A vector containing the translucency factors for the first polygon list. (A translucency factor of 0 is completely clear. The higher the translucency factor, the more opaque the polygon.)

Opaque2 – A vector containing the translucency factors for the second polygon list.

Output Keywords

Edge_List – The edge colors for the merged list.

Fill_List – The fill colors for the merged list.

Opaque_List – The translucency factors for the merged list.

Discussion

The merged lists returned by POLY_MERGE are suitable for input into POLYSHADE or POLY_PLOT, where they may be rendered in a single pass.

Examples

Spee the `sphere_demo3` demonstration program in `$WAVE_DIR/demo/arl`.

See Also

POLY_PLOT

For details on the POLYSHADE routine, see its description in the *PV-WAVE Reference*.

POLY_NORM Function

Returns a list of 3D points converted from data coordinates to normal coordinates.

Usage

result = POLY_NORM(*points*)

Input Parameters

points — A (3, *n*) array of points (or vertices) to transform.

Returned Value

result — The list of 3D points that has been converted from data coordinates to normal coordinates.

Keywords

None.

Discussion

POLY_NORM uses the system variables !X.S, !Y.S, and !Z.S to do the conversion. (These system variables are described in the *PV-WAVE Reference*.)

Examples

See the Examples section in the description of the POLY_C_CONV routine.

For other examples, see the following demonstration programs in `$WAVE_DIR/demo/arl`: `poly_demo1`, `sphere_demo3`, and `vol_demo4`.

See Also

POLY_DEV, POLY_TRANS

For more information, see *Coordinate Conversion* on page 193 of the *PV-WAVE User's Guide* and *Three Graphics Coordinate Systems* on page 59 of the *PV-WAVE User's Guide*.

POLY_PLOT Procedure

Renders a given list of polygons.

Usage

POLY_PLOT, *vertex_list, polygon_list, pg_num, winx, winy, fill_colors, edge_colors, poly_opaque*

Input Parameters

vertex_list – A (3, *n*) array containing the 3D coordinates of each vertex. Must be in device coordinates.

Tip To obtain device coordinates from data coordinates, use the POLY_NORM, POLY_TRANS, and POLY_DEV functions, in that order.

polygon_list – An array containing the number of sides for each polygon and the subscripts into the *vertex_list* array.

For more information on the above two parameters, see *Vertex Lists and Polygon Lists* on page 187 of the *PV-WAVE User's Guide.*

pg_num – The total number of polygons to plot.

winx, winy — The X and Y dimensions, respectively, of the current plot window in device coordinates.

Note The *winx* and *winy* parameters are ignored if the *Image* keyword is present.

fill_colors — The color(s) to fill the polygons with:

- If *fill_colors* contains fewer than *pg_num* elements, then all polygons are filled with the color specified by the first element in *fill_colors.*
- Otherwise, each polygon is filled with the corresponding color found in *fill_colors(i).*
- To prevent polygon fill, set *fill_colors* to –1. For example, *fill_colors* could contain:

255	Fill the first polygon with color 255.
200	Fill the second polygon with color 200.
–1	Don't fill the third polygon.
0	Fill the fourth polygon with color 0.

edge_colors — The color(s) to draw the polygon edges with. *edge_colors* works in the same manner as *fill_colors.*

To suppress the plotting of polygon edges, set *edge_colors* to –1.

Note Polygon edges are not plotted if the *Image* keyword is present.

poly_opaque — The translucency factor to use for plotting each polygon:

- If *poly_opaque* contains fewer than *pg_num* elements, then all polygons are plotted with the translucency factor specified by the first element in *poly_opaque.*
- Otherwise, each polygon is plotted with the corresponding translucency factor found in *poly_opaque(i).*
- To prevent translucency, set *poly_opaque* to –1.

A translucency factor of 0 is completely clear. The higher the translucency factor, the more opaque the polygon is. If the maximum value found in *Image* is 255 and if the maximum color value found in *fill_colors* is also 255, then a translucency factor of 255 is completely opaque.

Note The *Image* keyword must be used for *poly_opaque* to take effect.

Input Keywords

Image — On input, a 2D array containing the image on which to plot the polygons:

- If *Image* is not present, then the polygons are plotted immediately as generated in the current PV‑WAVE window.
- If *Image* is present, then no polygon edges are plotted and the *winx* and *winy* parameters are ignored.

ZClip — If this keyword is present and nonzero, then polygons that do not have at least one vertex in front of the view point are not plotted.

Output Keywords

Image — On output, contains the original image with the polygons plotted on it. This image may then be displayed using TV or other similar routines.

Discussion

POLY_PLOT renders a list of polygons. It is slower than the alternative procedure POLYSHADE, but it is more flexible:

- POLY_PLOT can draw the edges of the polygons, unlike POLYSHADE.
- POLY_PLOT does not fail if one or more polygons have a vertex outside the current plot window, unlike POLYSHADE.

POLY_PLOT uses a simple back-to-front sorting method to determine the polygon plotting order. It does not render polygons with light source shading, but it can plot opaque and translucent polygons. You can also specify the fill color and edge color for each polygon.

Example

See the Examples section in the description of the POLY_DEV routine.

For other examples, see the following demonstration programs in `$WAVE_DIR/demo/arl`: `sphere_demo2`, `sphere_demo3`, and `vol_demo4`.

See Also

POLY_NORM, POLY_TRANS, POLY_DEV, POLY_C_CONV

For details on the POLYSHADE routine, see its description in the *PV-WAVE Reference*.

POLYSHADE Function

Constructs a shaded surface representation of one or more solids described by a set of polygons.

Usage

result = POLYSHADE(*vertices, polygons*)

result = POLYSHADE(*x, y, z, polygons*)

Input Parameters

vertices — A (3, *n*) array containing the X, Y, and Z coordinates of each vertex. Coordinates may be in either data or normalized coordinates, depending on which keywords are present.

x, y, z — The X, Y, and Z coordinates of each vertex may alternatively be specified as three individual array expressions; X, Y, and Z must all contain the same number of elements.

polygons — An integer or longword array containing the indices of the vertices of each polygon. The vertices of each polygon should be listed in counterclockwise order when observed from outside the surface. The vertex description of each polygon is a vector of the form $[n, i_0, i_1, \ldots, i_{n-1}]$, and the array *polygons* is the concatenation of the lists of each polygon.

For example, to render a pyramid consisting of four triangles, *polygons* will contain 16 elements, made by concatenating four 4-element vectors of the form [*3, V0, V1, V2*]. *V0, V1,* and *V2* are the indices of the vertices describing each triangle.

Returned Value

result — A 2D byte array containing the shaded image.

Input Keywords

Data – Indicates that the vertex coordinates are in data units, the default coordinate system.

Mesh – When present and nonzero, a wire-frame mesh is drawn over the polygons, and they are not shaded.

Normal – Indicates that coordinates are in normalized units, within the 3D (0,1) cube.

Poly_Shades – Similar to the *Shades* keyword, except one shade per polygon is passed to POLYFILL rather than one shade per vertex.

Shades – An array expression, of the same number of elements as vertices, containing the color index at each vertex. The shading of each pixel is interpolated from the surrounding *Shades* values. For most displays, this keyword should be scaled into the range of bytes. If this keyword is omitted, light source shading is used.

T3D – Enables the 3D to 2D transformation contained in the homogeneous 4-by-4 matrix !P.T. If this keyword is set, the system variable !P.T must contain a valid transformation matrix.

XSize – The number of columns in the output image array. If omitted, sets the number of columns equal to the X resolution of the currently selected display device.

YSize – The number of rows in the output image array. If omitted, sets the number of rows equal to the Y resolution of the currently selected display device.

Caution If you are using a PostScript or other high resolution graphics device, you should explicitly specify the *XSize* and *YSize* parameters. Making the output image of full device size (the default) will result in an insufficient memory error.

Discussion

Note that you must set up a 3D coordinate system prior to calling POLYSHADE.

POLYSHADE constructs the shaded surface using the scan line algorithm. The shading model is a combination of diffuse reflection and depth cueing. Polygons are shaded in one of two ways:

- With constant shading, where each polygon is given a constant intensity.
- With Gouraud shading, where the intensity is computed at each vertex and then interpolated over the polygon.

Tip Use the SET_SHADING procedure to control the direction of the light source and other shading parameters.

Example

Function POLYSHADE is often used in conjunction with procedure SHADE_VOLUME for volume visualization. This example creates a volume dataset and renders an isosurface from that dataset.

```
vol = FLTARR(20, 20, 20)
```
Create a 3D single-precision, floating-point array.

```
FOR x = 0, 19 DO FOR y = 0, 19 $
   DO FOR z = 0, 19 DO $
   vol(x, y, z) = SQRT((x-10)^2 + (y-10)^2 + $
   (z-10)^2) + 1.5 * COS(z)
```
Create the volume dataset.

```
SHADE_VOLUME, vol, 7, v, p
```
Find the vertices and polygon at a contour level of 7.

```
SURFACE, FLTARR(2, 2), /Nodata, /Save, $
   Xrange = [0, 20], Yrange = [0, 20], $
   Zrange = [0, 20], Xstyle = 4, Ystyle = 4, $
   Zstyle = 4
```
Set up an appropriate 3D transformation.

```
image = POLYSHADE(v, p, /T3d)
```

Render the image. Note that the T3d keyword has been set so that the 3D transformation established by SCALE3 is used.

```
TV, image
```

Display the image.

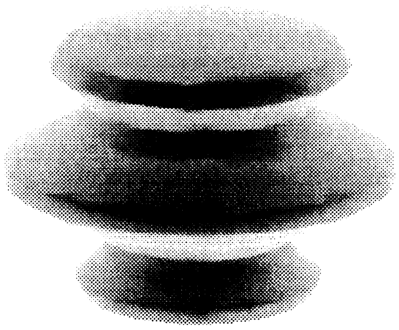


Figure 2-40 Isosurface at level 7 of volume dataset from example.

See Also

!P.T, SET_SHADING

For additional information on defining a coordinate system, see Chapter 4, *Displaying 3D Data*, in the *PV-WAVE User's Guide*.

POLY_SPHERE Procedure

Generates the vertex list and polygon list that represent a sphere.

Usage

POLY_SPHERE, *radius, px, py, vertex_list, polygon_list*

Input Parameters

radius – If *radius* is a scalar value, then all the polygons are generated at this radius.

If *radius* is a 2D (*m, n)* array, then the radius of each polygon is generated at the corresponding radius. The *radius* array is scaled to the dimensions (*px, py*) before use.

You can use the array returned by the GRID_SPHERE function as *radius* values.

px – A scalar value specifying the number of polygons around the equator.

py – A scalar value specifying the number of polygons around the meridian.

Output Parameters

vertex_list – A (3, *n*) array of polygon vertices.

polygon_list – The list of vertices for each polygon.

For more information, see *Vertex Lists and Polygon Lists* on page 187 of the *PV-WAVE User's Guide.*

Input Keywords

XMin – The longitude of the left edge of the portion of the polygon mesh you want to use (where on the sphere the polygon mesh is to be extracted). Should be in the range $-\pi$ to $+\pi$ radians (–180 to +180 degrees). The value is assumed to be in radians unless the *Degrees* keyword is set.

If *XMin* is omitted, a longitude of –π is mapped to the left edge of the polygon mesh for the entire sphere (when viewed from outside the sphere).

XMax – The longitude of the right edge of the portion of the polygon mesh you want to use (where on the sphere the polygon mesh is to be extracted). Should be in the range –π to +π radians (–180 to +180 degrees). The value is assumed to be in radians unless the *Degrees* keyword is set.

If *XMax* is omitted, a longitude of π is mapped to the right edge of the polygon mesh for the entire sphere (when viewed from outside the sphere).

YMin – The latitude of the bottom edge of the portion of the polygon mesh you want to use (where on the sphere the polygon mesh is to be extracted). Should be in the range –π/2 to +π/2 radians (–90 to +90 degrees). The value is assumed to be in radians unless the *Degrees* keyword is set.

If *YMin* is omitted, a latitude of –π/2 is mapped to the bottom edge of the polygon mesh for the entire sphere (when viewed from outside the sphere).

YMax – The latitude of the top edge of the polygon mesh. Should be in the range –π/2 to +π/2 radians (–90 to +90 degrees). The value is assumed to be in radians unless the *Degrees* keyword is set.

If *YMax* is omitted, a latitude of π/2 is mapped to the top edge of the polygon mesh for the entire sphere (when viewed from outside the sphere).

Degrees – If *Degrees* is present and nonzero, then the values for *XMin, XMax, YMin*, and *YMax* are in degrees instead of radians.

Discussion

The *vertex_list* and *polygon_list* generated by POLY_SPHERE are suitable for use with the POLYSHADE and POLY_PLOT rendering procedures.

To generate the polygons for a portion of a sphere, rather than an entire sphere, use the *XMin, XMax, YMin,* and *YMax* keywords. For example, to work with the central portion of the country from a map of the United States, you might use:

```
XMin=-110, XMax=-100, YMin=35, YMax=45
```

Examples

```
PRO sphere_demo1
```

This program displays an image warped onto a sphere.

```
xval = 512
yval = 512
img = BYTARR(xval, yval)
OPENR, 1, !Data_Dir + 'mandril.img'
READU, 1, img
CLOSE, 1
xval = 128
yval = 128
img = REBIN(img, xval, yval)
```

Read in the image and shrink it to a 128-by-128 array.

```
POLY_SPHERE, 1.0, xval, yval, vertex_list, $
   polygon_list
```

Define the sphere as a list of polygons.

```
WINDOW, 0, Colors=128
LOADCT, 4
CENTER_VIEW, Ax=(-75.0), Az=(-90.0), Zoom=0.9
```

Set up the viewing window and load the color table.

```
TVSCL, POLYSHADE(vertex_list, $
   polygon_list, /T3d, Shade=img)
```

Display the shaded surface representation of the data warped onto the sphere.

```
TVSCL, img
```

Display the original image in the corner of the window.

```
END
```

For other examples, see the following demonstration programs in `$WAVE_DIR/demo/arl`: `grid_demo5`, `sphere_demo2`, and `sphere_demo3`.

See Also

GRID_SPHERE, POLY_SURF

For details on the POLYSHADE routine, see its description in the *PV-WAVE Reference.*

POLY_SURF Procedure

Generates a 3D vertex list and a polygon list, given a 2D array containing Z values.

Usage

POLY_SURF, *surf_dat, vertex_list, polygon_list, pg_num*

Input Parameters

surf_dat – A 2D array containing Z values. The 3D polygon vertices are generated from this data.

Output Parameters

vertex_list – A (3, *n*) array containing the 3D coordinates of the polygon vertices (see Discussion below).

polygon_list – A 1D array containing the number of sides for each polygon, as well as the subscripts into the *vertex_list* array for the vertices of each polygon (see Discussion below).

pg_num – The total number of polygons defined by *vertex_list* and *polygon_list*. This parameter can be used as input into POLY_PLOT.

Keywords

None.

Discussion

POLY_SURF generates a list of polygons from a 2D array that contains Z values. All the polygons generated have four sides (and four vertices).

- The *vertex_list* array returned is suitable for input into the POLY_TRANS, POLY_NORM, POLY_DEV, POLY_PLOT and POLYSHADE procedures.
- The *polygon_list* array returned is suitable for input into the POLY_PLOT and POLYSHADE procedurFor more information, see *Vertex Lists and Polygon Lists* on page 187 of the *PV-WAVE User's Guide.*

Note

Examples

See the Examples section in the description of the POLY_DEV routine.

See Also

POLY_SPHERE

POLY_TRANS Function

Returns a list of 3D points transformed by a 4-by-4 transformation matrix.

Usage

result = POLY_TRANS(*points, trans*)

Input Parameters

points — A (3, *n*) array of points (or vertices) to transform.

trans — A (4, 4) array to transform the points with.

Returned Value

result — A list of 3D points transformed by a 4-by-4 transformation matrix.

Keywords

None.

Discussion

You can use the T3D, CENTER_VIEW, SET_VIEW3D, and VIEWER procedures to build the transformation matrix. The 4-by-4 matrix most often used is the system viewing matrix !P.T. (For more information, see the section *Overview of Transformation Matrices* in Chapter 5, *Displaying Images*, in the *PV-WAVE User's Guide*.

Examples

See the Examples section in the description of the POLY_DEV routine.

For other examples, see the following demonstration programs in `$WAVE_DIR/demo/arl`: `sphere_demo2`, `sphere_demo3`, and `vol_demo4`.

See Also

POLY_DEV, POLY_NORM

For more information, see *Coordinate Conversion* on page 193 of the *PV-WAVE User's Guide*.

POLYWARP Procedure

Standard Library procedure that calculates the coefficients needed for a polynomial image warping transformation.

Usage

POLYWARP, *xd, yd, xin, yin, deg, xm, ym*

Input Parameters

xd – The vector containing the X coordinates to be fit as a function of (*xin, yin*).

yd – The vector containing the Y coordinates to be fit as a function of (*xin, yin*).

xin – The vector containing the X independent coordinates. Must have the same number of points as *xd.*

yin – The vector containing the Y independent coordinates. Must have the same number of points as *yd.*

deg – The degree of the polynomial to be fitted to the data. The number of coordinate pairs formed by *xin* and *yin* must be greater than or equal to $(deg + 1)^2$.

Output Parameters

xm — A (*deg* + 1)-by-(*deg* + 1) array containing the coefficients of *xd* as a function of (*xin*, *yin*).

ym — A (*deg* + 1)-by-(*deg* + 1) array containing the coefficients of *yd* as a function of (*xin*, *yin*).

Keywords

None.

Discussion

POLYWARP calculates its transformation coefficients using the polynomial least-squares method. It returns the coefficients of the polynomial functions which best approximate the data:

- The *xm* polynomial array pertains to the X direction.
- The *ym* polynomial array pertains to the Y direction.

POLYWARP determines the coefficients *Ax(i, j)* and *Ay(i, j)* of these two polynomial functions:

$$X_{dep} = \sum_{i,j}^{deg} A_x(i,j) X^j_{indep} Y^i_{indep}$$

and

$$Y_{dep} = \sum_{i,j}^{deg} A_y(i,j) X^j_{indep} Y^i_{indep}$$

where A_x = *xm* and A_y = *ym*.

Tip *xm* (X coefficients) and *ym* (Y coefficients) can be used as input for the POLY_2D function. POLY_2D performs the actual warping of the image, using the X and Y transformation coefficients that you provide.

Example

```
image = BYTSCL(DIST(300))
WINDOW, XSize=300, YSize=300
TV, image
```

Create a test image and display it.

```
xin = [100, 200, 200, 100]
yin = [200, 200, 100, 100]
XYOUTS, 100, 200, '0', /Device
XYOUTS, 200, 200, '1', /Device
XYOUTS, 200, 100, '2', /Device
XYOUTS, 100, 100, '3', /Device
```

Create arrays describing four independent control points and plot these points on top of the image. These points describe a square, and represent the position of points in a calibration image.

```
xd = INTARR(4)
yd = INTARR(4)
FOR i=0,3 DO BEGIN
   PRINT, 'Pick warped point ', i
   CURSOR, xt, yt, /Device
   WAIT, 0.5
   xd(i) = xt
   yd(i) = yt
ENDFOR
```

Pick four dependent warping control points from the image; these points represent the calibration points as actually measured by an instrument, which, due to distortion, has warped them.

```
deg = 1
POLYWARP, xd, yd, xin, yin, deg, xm, ym
```

Perform linear (first degree) warping. POLYWARP will return xm and ym, the coefficients of the polynomial functions which describes this warping.

```
interp = 1
result = POLY_2D(image, xm, ym, interp)
```

Apply the polynomial functions calculated with POLYWARP to the first image, using bilinear interpolation.

```
TVSCL, result
```

Display the resulting image, which represents the image after correcting for instrument distortion.

See Also

POLY_2D

For more information on image processing, see Chapter 4, *Displaying 3D Data*, in the *PV-WAVE User's Guide*.

For additional information, see *Geometric Transformations* on page 167 of the *PV-WAVE User's Guide*.

POPD Procedure

Standard Library procedure that pops a directory from the top of a last-in, first-out directory stack.

Usage

POPD

Parameters

None.

Keywords

None.

Discussion

POPD changes the current working directory to the directory saved on the top of the directory stack. The stack is maintained by the PUSHD/POPD procedures. This top directory is then removed from the stack. (If you try to pop from an empty stack, an error message is displayed.)

Directories that have been pushed onto the stack are removed by the POPD procedure. The last directory pushed onto the stack is the first directory popped out of it. There is no limit to how deep directories may be stacked.

Example

In this example, PUSHD is used to change the current working directory to the `/subl/data` (UNIX) or `[.subl.data]` (VMS) subdirectories under the current working directory. The current working directory is pushed onto the directory stack before moving to the subdirectory. Procedure POPD is used to change the current working directory to the directory at the top of the directory stack. Thus, you are returned to the original working directory. Procedure PRINTD is used to view the current working directory and the directory stack before and after the execution of PUSHD and POPD.

```
PRINTD
```

Display the current working directory and the directory stack.

```
PUSHD, 'subl/data'
```

Push the current working directory onto the directory stack, and move to the subdirectory /sub1/data (UNIX) or [.sub1.data] (VMS).

```
PRINTD
```

Display the current working directory and the directory stack. Note that the top of the stack contains the previous working directory.

```
POPD
```

Move to the directory at the top of the directory stack. In this case, you are moved back to the original working directory.

```
PRINTD
```

Display the current working directory and the directory stack.

Under VMS, a path specification that is consistent with that used while at the VMS command line prompt can be used in the argument to PUSHD.

```
PUSHD, '[.subl.data]'
```

Push the current working directory onto the directory stack, and move to the subdirectory [.sub1.data] (VMS).

See Also

PUSHD, PRINTD, CD

PRINT, PRINTF Procedures

Perform output of ASCII data:

PRINT performs output to the standard output stream (PV-WAVE file unit –1).

PRINTF requires the output file unit to be specified.

Usage

PRINT, $expr_1$, ... , $expr_n$

PRINTF, *unit*, $expr_1$, ... , $expr_n$

Input Parameters

unit – The file unit to which the output will be sent.

***expr*$_i$** – The expressions to be output.

Input Keywords

Format – Allows the format of the output to be specified in precise detail, using a FORTRAN-style specification. FORTRAN-style formats are described in Appendix A, *FORTRAN and C Format Strings*, in the *PV-WAVE Programmer's Guide*.

If the *Format* keyword is not present, PV-WAVE uses its default rules for formatting the output. These rules are described in Table 8-7 on page 164 of the *PV-WAVE User's Guide*.

Example

In this example, PRINTF is used to write 10 integers to a file. The integers are then read from the file and displayed using the PRINT procedure. The *Format* keyword is used with the PRINT procedure to place one space after each integer as it is written to the screen.

```
nums = INDGEN(10)
```

Create a 10-element integer vector that is initialized to the values of its one-dimensional subscripts.

```
OPENW, unit, 'printex.dat', /Get_Lun
```

Open the printex.dat file for writing.

```
PRINTF, unit, nums
```

Write the integers in nums to the file.

```
POINT_LUN, unit, 0
```

Rewind the file to the beginning.

```
n = INTARR(10)
```

Create a 10-element integer vector.

```
READF, unit, n
```

Read the contents of printex.dat into n.

```
PRINT, n, Format = '(10(i1, 1x))'
0 1 2 3 4 5 6 7 8 9
```

Display the formatted contents of n.

```
FREE_LUN, unit
```

Close the file and free the file unit number.

See Also

DT_PRINT

PRINTD Procedure

Standard Library procedure that lists the directories located in the directory stack, and the current working directory.

Usage

PRINTD

Input Parameters

None.

Keywords

None.

Example

See the example for POPD.

See Also

PUSHD, POPD, CD

PROFILE Function

Standard Library function that extracts a profile from an image.

Usage

result = PROFILE(*image*)

Input Parameters

image – The input image array. May be any type except string or complex.

Returned Value

result – A floating-point vector containing the profile data points. It is of the same data type as *image*.

Input Keywords

XStart – The starting X location of the lower-left corner of the image in the window.

YStart – The starting Y location of the lower-left corner of the image in the window.

Nomark – If set to 1, inhibits marking the selected line on the image display.

Discussion

To use PROFILE, mark two endpoints on the image display with the cursor by clicking on any mouse button. PROFILE then extracts the values of the image elements along a line connecting the endpoints and returns these values as a floating-point vector.

Example

This example uses the PROFILE function to retrieve a vector of image values.

```
OPENR, unit, FILEPATH('aerial_demo.img', $
   Subdir = 'data'), /Get_Lun
```
Open the file containing the image.

```
img = BYTARR(512, 512)
```
Create an array large enough to hold the image.

```
READU, unit, img
```
Read the image data.

```
WINDOW, 0, Xsize = 512, Ysize = 512
```
Create a window to display an image from the file.

```
TV, img
```
Display the first image from the file.

```
HIST_EQUAL_CT, img
```

```
vals = PROFILE(img)
```
Retrieve a profile from the file.

```
INFO, vals
```
Examine the type and number of elements in the returned vector.

```
FREE_LUN, unit
```
Close the file and free the file unit number.

See Also

PROFILES, TV, TVSCL

PROFILES Procedure

Standard Library procedure that lets you interactively draw row or column profiles of the image displayed in the current window. The profiles are displayed in a new window, which is deleted when you exit the procedure.

Usage

PROFILES, *image*

Input Parameters

image – The image array displayed in the current window. May be any data type except string or complex. The profile graphs are made from this array.

Input Keywords

Order – Controls the direction of *image* transfer. Set to 1 to have *image* written top-down. Set to 0 to have *image* written bottom-up. The default is the current value of the system variable !Order.

Sx – The starting X value of the image within the window. If omitted, 0 is assumed.

Sy – The starting Y value of the image within the window. If omitted, 0 is assumed.

Wsize – The size of the new profile window as a fraction or multiple of the default size, which is 640-by-512.

Discussion

To use PROFILES, place the cursor in the original image window. Move the cursor so that the row or column profile is updated interactively. Press the left mouse button to toggle between displaying a row or column profile. Press the right mouse button to exit the procedure.

Example

To create a profile window for the cerebral image found in the PV-WAVE directory `wave/data`, display this image in the current window and then enter:

```
cereb = BYTARR(512, 512)
```

Create a 512-by-512 byte array called cereb.

```
OPENR, 1, !Data_Dir + 'cereb_demo.img'
```

Open the file for reading using a logical unit number of 1.

```
READU, 1, cereb
```

Read data from the file into the variable cereb.

```
TV, cereb
```

Display the image.

```
PROFILES, cereb
```

Display the profile window.

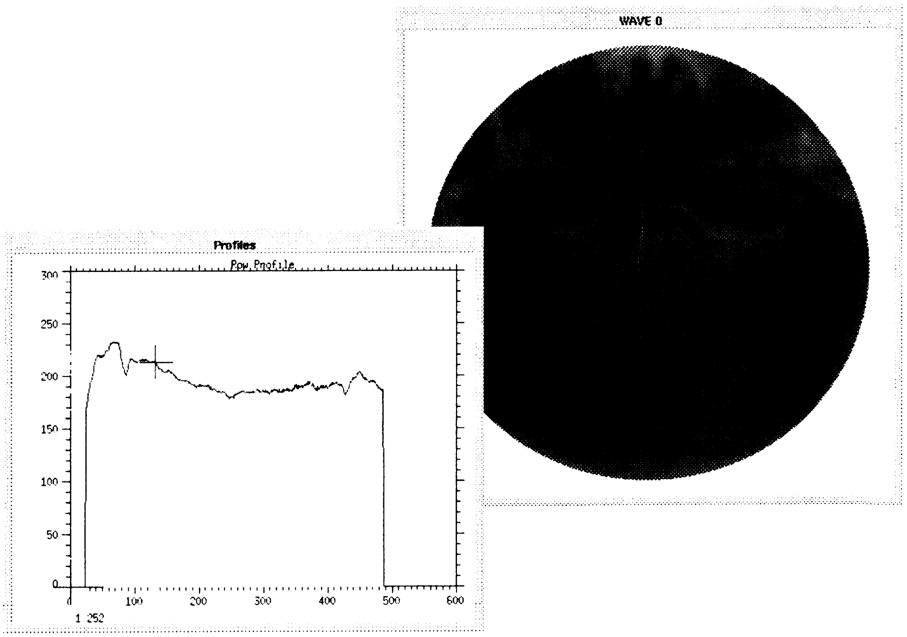


Figure 2-41 Profile plot taken from the image.

See Also

PROFILE

PROMPT Procedure

Standard Library procedure that sets the interactive prompt.

Usage

PROMPT, *string*

Input Parameters

string – A scalar string defining the new prompt.

Keywords

None.

Discussion

PROMPT sets the interactive prompt to *string*, and also changes the value of the system variable !Prompt to that string.

If no parameter is supplied, the prompt string reverts to `WAVE>`.

Example

```
WAVE> PROMPT, 'YOU_RANG?> '
YOU_RANG?> PROMPT
WAVE>
```

See Also

!Prompt

PSEUDO Procedure

Standard Library procedure that creates a pseudo color table based on the Hue, Lightness, Saturation (HLS) color system.

Usage

PSEUDO, *ltlo, lthi, stlo, sthi, hue, lp* [, *rgb*]

Input Parameters

ltlo – The starting color lightness or intensity, expressed as 0 to 100 percent. Full lightness (the brightest color) is 100 percent.

lthi – The ending color lightness or intensity, expressed as 0 to 100 percent.

stlo – The starting color saturation, expressed as 0 to 100 percent. Full saturation (undiluted or pure color) is expressed as 100 percent.

sthi – The ending color saturation, expressed as 0 to 100 percent.

hue – The starting hue. It ranges from 0 to 360 degrees, with Red equal to 0, Green equal to 120, and Blue equal to 240.

lp – The number of loops of hue to make in the color cone. Does not have to be an integer.

Output Parameters

rgb – A 256-by-3 integer output array containing the red, green, and blue vector values loaded into the color tables. The Red vector is equal to RGB(*, 0), the Green vector is RGB(*, 1), and the Blue vector is RGB(*, 2).

Keywords

None.

Discussion

The pseudo-color mapping generated by PSEUDO is done by the following three steps:

❑ Map the HLS coordinate space to the Lightness, Absorbance, Saturation (LAS) coordinate space.

❑ Find *n* colors (in this case 256) spread out along a helix that spans this LAS space. These colors are supposedly a near maximal entropy mapping for the eye, given a particular *n*.

❑ Map the LAS coordinate space into the Red, Green, Blue (RGB) coordinate space.

The result, given *n* desired colors, is that *n* discrete values are loaded into the Red color vector, *n* discrete values are loaded into the Green color vector, and *n* discrete values are loaded into the Blue color vector.

See Also

HLS, LOADCT, TVLCT

For background information about color systems, see *Understanding Color Systems* on page 305 of the *PV‑WAVE User's Guide.*

PUSHD Procedure

Standard Library procedure that pushes a directory onto the top of a last-in, first-out directory stack.

Usage

PUSHD [, *directory*]

Input Parameters

directory — A scalar string specifying the path of the new working directory.

- If not specified, pushes the current directory onto the stack. The current directory remains the working directory.
- If specified as a null string, pushes the current directory onto the stack and the new working directory is changed to the user's home directory.

Keywords

None.

Discussion

Directories that have been pushed onto the stack by PUSHD can be removed with POPD. The last directory pushed onto the stack is the first directory popped out of it. There is no limit to how deep directories may be stacked.

Example

See the example for POPD.

See Also

POPD, PRINTD, CD

Multivolume Index

This is a multivolume index that includes references to the *PV-WAVE User's Guide* (UG), *PV-WAVE Programmer's Guide* (PG), and both volumes of the *PV-WAVE Reference* (R1 and R2).