Wavelet Toolbox Release Notes

The "Wavelet Toolbox 3.0 Release Notes" on page 1-1 describe the changes introduced in the latest version of the Wavelet Toolbox. The following topics are discussed in these Release Notes:

- "New Features" on page 1-2
- "Major Bug Fixes" on page 1-5
- "Upgrading from an Earlier Release" on page 1-6

If you are upgrading from a version earlier than Release 13 with Service Pack 1, you should also see these sections:

- "Wavelet Toolbox 2.2 Release Notes" on page 2-1
- "Wavelet Toolbox 2.1 Release Notes" on page 3-1
- "Wavelet Toolbox 2.0 Release Notes" on page 4-1

Printing the Release Notes

If you would like to print the Release Notes, you can link to a PDF version.

Contents

Wavelet Toolbox 3.0 Release Notes

1

Wavelet Toolbox 2.2 Release Notes

2

Wavelet Toolbox 2.1 Release Notes

3

Wavelet Toolbox 2.0 Release Notes

4

1

Wavelet Toolbox 3.0 Release Notes

New Features

This section summarizes the new features and enhancements introduced in the Wavelet Toolbox 3.0.

For information about Wavelet Toolbox features that are incorporated from Version 2.2, see "New Features" on page 2-2 in the Wavelet Toolbox 2.2 Release Notes.

Wavelet Design for CWT

The **New Wavelet for CWT** tool designs a new wavelet adapted to a given pattern using least squares optimization. The new wavelet can be used for accurate pattern detection using the continuous wavelet transform (cwt). This new tool is useful for creating new wavelets for accurate 1-D pattern detection. From the command line, use the pat2cwav function.

Image Fusion

The **Image Fusion** tool performs fusion of two images. Image fusion using wavelets merges the wavelet decompositions of two original images using various fusion methods applied to approximations coefficients and details coefficients. Examples of uses of this tool are creating a new image from two different images and restoring an image from two fuzzy versions of an original image. From the command line, use the wfusimg and wfusmat functions to fuse two images and fuse two matrices or arrays, respectively.

Fractional Brownian Generation 1-D

The **Fractional Brownian Generation 1-D** tool performs the random generation of fractional Brownian motion, which is a useful model for Internet traffic and financial series. From the command line, use the wfbm and wfbmesti functions to synthesize and perform parameter estimation of fractional Brownian motion, respectively.

Lifting Methods

You can use lifting methods to design new wavelets. The new lifting methods also allow integer-to-integer wavelet transforms and transforms using different length decomposition high-pass and low-pass filters. Five groups of new lifting functions are included in the Wavelet Toolbox version 3.0:

- Key lifting scheme structures
  - `addlift`—Add primal or dual elementary lifting steps to a lifting scheme
  - `displs`—Display a lifting scheme
  - `lsinfo`—Information about lifting schemes
- Biorthogonal quadruplets of filters
  - `bswfun`—Compute and plot biorthogonal "scaling and wavelet" functions
  - `filt2ls`—Transform a quadruplet of filters to a lifting scheme
  - `liftfilt`—Apply elementary lifting steps on quadruplet of filters
  - `ls2filt`—Transform a lifting scheme to a quadruplet of filters
- Orthogonal or biorthogonal ("true") wavelets and "lazy" wavelets.
  - `liftwave`—Provides lifting scheme associated to a wavelet
  - `wave2lp`—Provides Laurent polynomials associated to a wavelet
  - `wavenames`—Provides wavelet names available for LWT
- Direct and inverse Lifting Wavelet Transform (LWT)
  - `lwt`—1-D Lifting Wavelet Transform
  - `lwt2`—2-D Lifting Wavelet Transform
  - `lwtcoef`—Extract or reconstruct 1-D LWT wavelet coefficients
  - `lwtcoef2`—Extract or reconstruct 2-D LWT wavelet coefficients
  - `ilwt`—Inverse 1-D Lifting Wavelet Transform
  - `ilwt2`—Inverse 2-D Lifting Wavelet Transform
- Laurent polynomials and matrices (see Note below)
  - `laurmat`—Constructor for the class LM of Laurent Matrices
  - `laurpoly`—Constructor for the class LP of Laurent Polynomials

Note If you saved `laurmat` or `laurpoly` objects using the names `lm` or `lp`, respectively, in the Beta release, you must rename them to `laurmat` or `laurpoly`, respectively, in this release of the Wavelet Toolbox 3.0.

Speed Enhancements

Many functions, including those involving decomposition and reconstruction, have been enhanced so they run more efficiently.

New Extension Modes for DWT

Four new extension modes are available for dwt, which allows specifying half- or whole-point symmetry, or half- or whole-point anti-symmetry. See dwtmode. These new extension modes are supported by both wextend to extend or truncate signal or images, and by the corresponding GUI tools: **Signal Extension** and **Image Extensio**n.

New Supported Image Formats

Images stored using JPEG, TIFF, PCX, and others can be directly loaded into the Wavelet Toolbox GUI.

Images stored in uint8 format can be used in all the 2-D tools.

Images stored in True Colour mode are converted automatically in indexed mode when loaded in the 2-D tools. See the Wavelet Toolbox documentation on working with images for more information.

Major Bug Fixes

The Wavelet Toolbox 3.0 includes several bug fixes made since Version 2.2. This section describes the particularly important Version 3.0 bug fixes.

If you are upgrading from a version earlier than Version 2.2, you also should see the bug fix summary for the Wavelet Toolbox 2.2 Release Notes.

Complex Wavelets

Numeric values associated with the `fbsp` and `shan` wavelet families (in particular, the `shanwavf`, `fbspwavf`, and `scal2frq` functions) were incorrect and have been fixed.

Density Estimation 1-D Normalization

An omitted normalization step has been added in the **Density Estimation 1-D** tool.

Upgrading from an Earlier Release

There are no upgrade issues involved in upgrading from the Wavelet Toolbox 2.2 to Version 3.0.

If you are upgrading from a version earlier than Version 2.0, you should see "Upgrading from an Earlier Release" on page 4-10 of the Wavelet Toolbox 2.0 Release Notes.

2

Wavelet Toolbox 2.2 Release Notes

New Features

This section summarizes the new features and enhancements introduced in the Wavelet Toolbox 2.2.

For information about Wavelet Toolbox features that are incorporated from Version 2.1, see "New Features" on page 3-2 of the Wavelet Toolbox 2.1 Release Notes.

New and Enhanced Functions

CFS2WPT

`cfs2wpt`, a new function for building a wavelet packet tree object from a set of coefficients has been added.

WENERGY and WENERGY2

`wenergy` and `wenergy2`, two new functions for calculating the energy represented by the approximation and details coefficients for 1-D and 2-D wavelets, respectively, have been added.

WENTROPY Enhancement

The `wentropy` function now includes an option for using your own entropy function, including passing a parameter in.

WAVEFUN2 Enhancement

An option to product plots has been added to `wavefun2`.

Loading .wav and .au files

You can now load `.wav` and `.au` files directly into the Wavelet Toolbox GUI using `wavread` and `auread`, respectively.

Major Bug Fixes

You can see a list of the particularly important Version 2.2 bug fixes. If you are viewing these Release Notes in PDF form, please refer to the HTML form of the Release Notes, using either the Help browser or the MathWorks Web site and use the link provided.

3

Wavelet Toolbox 2.1 Release Notes

New Features

This section introduces the new features and enhancements added in the Wavelet Toolbox 2.1 since the Wavelet Toolbox 2.0 (Release 12.0).

For information about Wavelet Toolbox features that are incorporated from Version 2.0, see "New Features" on page 4-2 of the Wavelet Toolbox 2.0 Release Notes.

disp

The new `disp` method displays information for a WPTREE object.

wavefun2

The new `wavefun2` function returns the 2-D scaling and wavelet functions from tensor products of 1-D scaling and wavelet functions.

GUI Improvements

The GUI menus have been reorganized and improved. See Appendix A, "GUI Reference" in the *Wavelet Toolbox User's Guide* for more information.

Major Bug Fixes

The Wavelet Toolbox includes several bug fixes, including the following descriptions (online only) of particularly important bug fixes.

Upgrading from an Earlier Release

There are no upgrade issues moving from Wavelet Toolbox 2.0 (Release 12.0) to the Wavelet Toolbox 2.1.

See "Upgrading from an Earlier Release" on page 4-10 for information about upgrade issues involved in moving from the Wavelet Toolbox 1.2 (Release 11.0) to the Wavelet Toolbox 2.1.

4

Wavelet Toolbox 2.0 Release Notes

New Features

This section introduces the new features and enhancements added in the Wavelet Toolbox 2.0 since the Wavelet Toolbox 1.2 (Release 11.0).

This section is organized into the following subsections:

- "New Visual Interface Tools" on page 4-2
- "New Wavelets" on page 4-5
- "New Functions" on page 4-6
- "Other Enhancements" on page 4-8

New Visual Interface Tools

The Wavelet Toolbox 2.0 introduces several new visual interfaces to facilitate wavelet analysis.

Continuous Wavelet 1-D

The Continuous Wavelet 1-D tool has two new axes.

The first new axis, **Coefficients Line**, displays the coefficient line plot corresponding to a scale selected using the mouse. This functionality is useful for exploring the continuous wavelet coefficients.

The second new axis, **Local Maxima Lines**, displays the coefficient lines corresponding to the chaining across scales of the coefficients local maxima. This functionality gives an interesting skeleton of the continuous wavelet coefficients. An automatic scale-to-frequency translator is now available using the mouse.

Complex Continuous Wavelet 1-D

The **Complex Continuous Wavelet 1-D** tool performs continuous wavelet analysis of real signals using complex wavelets. For both the modulus and the angle of the wavelet coefficients, three axes are displayed:

- The coefficients (modulus or angle)
- A coefficient line plot corresponding to a scale selected using the mouse
- The coefficient lines corresponding to the chaining across scales of the local maxima

An automatic scale-to-frequency translator is now available using the mouse. This new tool is useful when the data processing requires careful attention to phase information.

Signal De-Noising Using SWT 1-D

The **Stationary Wavelet Transform De-noising 1-D** tool performs translation invariant de-noising of signals. This new tool is useful when the signal to be recovered contains some isolated discontinuities. The basic idea is to average many slightly different discrete wavelet de-noising procedures.

Image De-Noising Using SWT 2-D

The **Stationary Wavelet Transform De-noising 2-D** tool performs translation invariant de-noising of images. This new tool is useful for image de-noising and dramatically improves the performance obtained using simple de-noising strategies. The basic idea is to average many slightly different discrete wavelet de-noising procedures.

Local Variance Adaptive Thresholding 1-D

This tool allows you to define time-dependent thresholds level by level, thereby increasing the capabilities of the de-noising strategies. A graphical editor helps you define a convenient signal segmentation.

This tool is added to the graphical interfaces involving wavelet or stationary wavelet coefficient thresholding (DWT 1-D De-noising and Compression, SWT 1-D De-noising, Density, and Regression estimation).

This new tool is useful for de-noising signals generated according to the classical noisy model with some kind of nonstationary variance noise.

Density Estimation

The **Density Estimation 1-D** tool performs wavelet based density estimation. This new tool is useful for data coming from an irregular underlying density function. For this kind of data, wavelet methods overcome the traditional histogram or kernel methods.

Regression Estimation

The **Regression Estimation 1-D** tool performs wavelet based regression estimation for two different underlying models: the fixed design model, and the random design model. This tool provides a visual interface for exploring some de-noising schemes for equally or unequally sampled data. It is useful for de-noising data observed at unequally spaced time instants or for estimating the nonlinear relationships between two variables. It can also be used to smooth data.

Wavelet Coefficients Selection 1-D

The **Wavelet Coefficients Selection 1-D** tool performs wavelet reconstruction schemes based on various wavelet coefficient selection strategies:

• *Global* selection of biggest coefficients (in absolute value)

• *By level* selection of biggest coefficients

• *Automatic* selection of biggest coefficients

• *Manual* selection of coefficients

This new tool is useful for stepwise selection of coefficients for manual signal compression.

Wavelet Coefficients Selection 2-D

The **Wavelet Coefficients Selection 2-D** tool performs wavelet reconstruction schemes based on various wavelet coefficient selection strategies:

• *Global* selection of biggest coefficients (in absolute value)

• *By level* selection of biggest coefficients

• *Automatic* selection of biggest coefficients

This new tool is useful for stepwise selection of coefficients for manual image compression.

Signal Extension/Truncation

The **Signal Extension** tool performs one-dimensional signal extension using various available extension methods: periodic, symmetric, smooth, and zero-padding. This tool also allows the truncation of a signal.

Image Extension/Truncation

The **Image Extension** tool performs two-dimensional image extension using various available extension methods: periodic, symmetric, smooth, and zero-padding. This tool also allows the truncation of an image.

Residuals Display

The **Residuals** tool displays the residuals obtained after a de-noising or compression procedure with some usual frequency diagrams and characteristics, as well as time-series diagrams. This new tool is added to the visual interface to be used with wavelet, wavelet packet, stationary wavelet coefficients, and thresholding.

Dynamic Visualization Tool

The Dynamic Visualization Tool includes a new toggle button, **View Axes**, that launches a palette for viewing an axis in "full size." Once selected a figure appears and the push buttons assume the position (and relative size) of the axes on the current figure. This functionality is useful when the axes dimensions are small, which happens often in compression and de-noising.

New Wavelets

Note See "Advanced Topics," in the *Wavelet Toolbox User's Guide* for details about these wavelets.

Wavelet (Short Name)	Description
cgau	Complex Gaussian wavelets (derivatives of the complex Gaussian function)
cmor	Complex Morlet wavelets
dmey	Discrete Meyer wavelet (FIR based approximation of the Meyer wavelet)
fbsp	Complex frequency B-spline wavelets

Wavelet (Short Name)	Description
gaus	Gaussian wavelets (derivatives of the Gaussian probability density function)
rbio	Reverse Biorthogonal wavelets (Reverse Biorthogonal wavelets based on bior)
shan	Complex Shannon wavelets
sym	Symlets (now available from sym2 to sym45)

New Functions

Stationary Wavelet Transforms

Function	Description
iswt	Inverse discrete stationary wavelet transform 1-D
iswt2	Inverse discrete stationary wavelet transform 2-D
swt	Discrete stationary wavelet transform 1-D
swt2	Discrete stationary wavelet transform 2-D

Thresholds for 1-D and 2-D De-noising and Compression

Function	Description
wbmpen	Compute threshold for wavelet, 1-D or 2-D, de-noising using penalization strategy
wdcbm	Compute thresholds for wavelet 1-D de-noising or compression using Birgé-Massart strategy
wdcbm2	Compute thresholds for wavelet 2-D de-noising or compression using Birgé-Massart strategy

Function	Description
wpbmpen	Compute threshold for wavelet packet, 1-D or 2-D, de-noising using penalization strategy
wthrmngr	Threshold settings manager

General Tree Object Functions

General tree object functions are used for Wavelet Packets 1-D and 2-D. They can also be used in a more general context involving tree objects.

Function	Description
dtree	Constructor for the class DTREE (Data Tree)
get	Get tree objects field contents
ntree	Constructor for the class NTREE (N-ary Tree)
plot	Graphical tree-management utility
read	Read values in tree object fields
set	Set tree objects field contents
wptree	Constructor for the class WPTREE (Wavelet Packet Tree)
write	Write values in tree object fields

The plot function opens a window and displays the tree. This window is a visual tool for splitting, merging, and visualizing each node of the tree.

Wavelet Utilities

Function	Description
centfrq	Compute wavelet center frequency
scal2frq	Convert scale to frequency

Signal Processing Utility

Function	Description
wvarchg	Find variance change points

Other Enhancements

Complex CWT
The cwt function performs continuous wavelet analysis of a real signal using a real or complex wavelet.

Threshold Settings Using the Visual Interface
The threshold lines in the de-noising and compression tools can be dragged using the mouse. The corresponding control buttons (edits, sliders, etc.) are automatically updated.

New De-noising and Compression Methods
New methods for de-noising and compression tools using the visual interface are available in Wavelet 1-D, Wavelet 2-D, Wavelet Packet 1-D, and Wavelet Packet 2-D.

Saving De-noising and Compression Parameters
In most of the menus, **Save** options are available. When signals, coefficients, or decompositions are obtained using de-noising or compression, the related parameters (wavelet name and thresholds) are now saved when the save operation is performed.

Length or Size Information
In most windows, a frame containing the analysis parameters displays in the upper right corner. In addition to the signal or image name, the length of the signal or the size of the image now displays.

Menus and Toolbar
The MATLAB default toolbar and menus displayed in figures are now available in most windows updated with the specific wavelet-oriented features.

New Extension Modes for DWT

Command to Set the Mode	Description
dwtmode('sym')	Set the DWT mode to symmetrization (new default mode, boundary value replication)
dwtmode('zpd')	Set the DWT mode to zero padding
dwtmode('spd') or dwtmode('sp1')	Set the DWT mode to smooth padding of order 1 (first derivative interpolation at the edges)
dwtmode('sp0')	Set the DWT mode to smooth padding of order 0 (constant extension at the edges)
dwtmode('ppd')	Set the DWT mode to periodic padding (periodic extension at the edges)

The five modes above are applicable for both 1-D and 2-D extensions. The associated DWT is slightly redundant for an arbitrary length signal. The following mode sets the DWT to periodization.

```
dwtmode('per')
```

This option produces the smallest wavelet decomposition. All functions that use the DWT (i.e., Discrete Wavelet (1-D & 2-D) or Wavelet Packet (1-D & 2-D)) use the specified DWT extension mode.

Changing the default extension mode. The default extension mode is 'sym' (boundary value replication). This default can be changed. The default mode is loaded from the file DWTMODE.DEF if it exists.

If not, the file DWTMODE.CFG (in the toolbox/wavelet/wavelet directory) is used.

dwtmode('save',mode) saves mode as the new default mode in the file DWTMODE.DEF (all the files named DWTMODE.DEF are deleted before saving).

dwtmode('save') is equivalent to dwtmode('save',currentMode).

Upgrading from an Earlier Release

This section describes the upgrade issues involved in moving from the Wavelet Toolbox 1.2 to the Wavelet Toolbox 2.0.

Default Extension Mode

The new default extension mode for DWT is `'sym'` (see "New Extension Modes for DWT"). If you want to restore the default mode used in earlier versions, you have to execute the `dwtmode` function. `dwtmode('save','zpd')` saves `'zpd'` extension mode as the default mode in the file `DWTMODE.DEF`.

Wavelet Packet Structures and Obsolete Functions

`wtbxmngr('V1')` lets you use earlier versions of wavelet packets data structures and functionality, as well as the following obsolete functions: `dwtper`, `idwtper`, `maketree`, `wdatamgr`, `dwtper2`, `idwtper2`, and `plottree`.

The obsolete functions are located in the `$MATLAB/toolbox/wavelet/ waveobsolete` directory, where `$MATLAB` is the root installation directory of MATLAB.

`wtbxmngr('V2')` restores the new version of wavelet packet data structures and functionality, and disables the obsolete functions.

Note Although the Wavelet Toolbox 2.0 maintains some compatibility with earlier versions, you should avoid using `wtbxmngr('V1')`, because future releases may not include it.