Package ‘Rwave’

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Title Time-Frequency Analysis of 1-D Signals

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Depends R (>= 2.14)

Description A set of R functions which provide an environment for the Time-Frequency analysis of 1-D signals (and especially for the wavelet and Gabor transforms of noisy signals). It was originally written for Splus by Rene Carmona, Bruno Torresani, and Wen L. Hwang, first at the University of California at Irvine and then at Princeton University. Credit should also be given to Andrea Wang whose functions on the dyadic wavelet transform are included. Rwave is based on the book: ``Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S'', by Rene Carmona, Wen L. Hwang and Bruno Torresani (1998, eBook ISBN:978008053942), Academic Press.

URL http://www.orfe.princeton.edu/~rcarmona/TFbook/tfbook.html,

http://r-forge.r-project.org/projects/rwave/

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R topics documented:

`A0` *Transient Signal*

Description

Transient signal.

Usage

```
data(A0)
```

Format

A vector containing 1024 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(A0)
plot.ts(A0)
```

`A4` *Transient Signal*

Description

Transient signal.

Usage

```
data(A4)
```

Format

A vector containing 1024 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(A4)
plot.ts(A4)
```

`adjust.length` *Zero Padding*

Description

Add zeros to the end of the data if necessary so that its length is a power of 2. It returns the data with zeros added if nessary and the length of the adjusted data.

Usage

```
adjust.length(inputdata)
```

Arguments

`inputdata`	either a text file or an S object containing data.

Value

Zero-padded 1D array.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

`amber7` *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(amber7)
```

Format

A vector containing 7000 observations.

Source

See discussions in the text of "Practical Time-Frequency Analysis".

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(amber7)
plot.ts(amber7)
```

`amber8` *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(amber8)
```

Format

A vector containing 7000 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(amber8)
plot.ts(amber8)
```

---

amber9 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(amber9)
```

Format

A vector containing 7000 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(amber9)
plot.ts(amber9)
```

B0 *Transient Signal*

Description

Transient signal.

Usage

```
data(B0)
```

Format

A vector containing 1024 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(B0)
plot.ts(B0)
```

B4 *Transient Signal*

Description

Transient signal.

Usage

```
data(B4)
```

Format

A vector containing 1024 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(B4)
plot.ts(B4)
```

---

back1.000 *Acoustic Returns*

Description

Acoustic returns from natural underwater clutter.

Usage

```
data(back1.000)
```

Format

A vector containing 7936 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(back1.000)
plot.ts(back1.000)
```

`back1.180` *Acoustic Returns*

Description

Acoustic returns from ...

Usage

```
data(back1.180)
```

Format

A vector containing 7936 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(back1.180)
plot.ts(back1.180)
```

`back1.220` *Acoustic Returns*

Description

Acoustic returns from an underwater metallic object.

Usage

```
data(back1.220)
```

Format

A vector containing 7936 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(back1.220)
plot.ts(back1.220)
```

---

backscatter.1.000 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(backscatter.1.000)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(backscatter.1.000)
plot.ts(backscatter.1.000)
```

backscatter.1.180 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(backscatter.1.180)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(backscatter.1.180)
plot.ts(backscatter.1.180)
```

backscatter.1.220 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(backscatter.1.220)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(backscatter.1.220)
plot.ts(backscatter.1.220)
```

`C0` *Transient Signal*

Description

Transient signal.

Usage

```
data(C0)
```

Format

A vector containing 1024 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(C0)
plot.ts(C0)
```

C4 — *Transient Signal*

Description

Transient signal.

Usage

```
data(C4)
```

Format

A vector containing 1024 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(C4)
plot.ts(C4)
```

cfamily — *Ridge Chaining Procedure*

Description

Chains the ridge estimates produced by the function `crc`.

Usage

```
cfamily(ccridge, bstep=1, nbchain=100, ptile=0.05)
```

Arguments

ccridge	unchained ridge set as the output of the function crc
bstep	maximal length for a gap in a ridge.
nbchain	maximal number of chains produced by the function.
ptile	relative threshold for the ridges.

Details

crc returns a measure in time-frequency (or time-scale) space. cfamily turns it into a series of one-dimensional objects (ridges). The measure is first thresholded, with a relative threshold value set to the input parameter ptile. During the chaining procedure, gaps within a given ridge are allowed and filled in. The maximal length of such gaps is the input parameter bstep.

Value

Returns the results of the chaining algorithm

ordered map	image containing the ridges (displayed with different colors)
chain	2D array containing the chained ridges, according to the chain data structure chain[,1]: first point of the ridge chain[,2]: length of the chain chain[,3:(chain[,2]+2)]: values of the ridge
nbchain	number of chains produced by the algorithm

References

See discussion in text of "Practical Time-Frequency Analysis".

See Also

crc for the ridge estimation, and crcrec, gcrcrec and scrcrec for corresponding reconstruction functions.

Examples

```
## Not run:
   data(HOWAREYOU)
 plot.ts(HOWAREYOU)

cgtHOWAREYOU <- cgt(HOWAREYOU,70,0.01,100)

clHOWAREYOU <- crc(Mod(cgtHOWAREYOU),nbclimb=1000)

cfHOWAREYOU <- cfamily(clHOWAREYOU,ptile=0.001)
image(cfHOWAREYOU$ordered > 0)

## End(Not run)
```

cgt — *Continuous Gabor Transform*

Description

Computes the continuous Gabor transform with Gaussian window.

Usage

```
cgt(input, nvoice, freqstep=(1/nvoice), scale=1, plot=TRUE)
```

Arguments

`input`	input signal (possibly complex-valued).
`nvoice`	number of frequencies for which gabor transform is to be computed.
`freqstep`	Sampling rate for the frequency axis.
`scale`	Size parameter for the window.
`plot`	logical variable set to TRUE to display the modulus of the continuous gabor transform on the graphic device.

Details

The output contains the (complex) values of the gabor transform of the input signal. The format of the output is a 2D array (signal_size x nb_scales).

Value

continuous (complex) gabor transform (2D array).

Warning

freqstep must be less than 1/nvoice to avoid aliasing. freqstep=1/nvoice corresponds to the Nyquist limit.

References

See discussion in text of "Practical Time-Frequency Analysis".

See Also

`cwt`, `cwtp`, `DOG` for continuous wavelet transforms. `cwtsquiz` for synchrosqueezed wavelet transform.

Examples

```
data(HOWAREYOU)
   plot.ts(HOWAREYOU)

cgtHOWAREYOU <- cgt(HOWAREYOU,70,0.01,100)
```

---

ch *Chen's Chirp*

Description

Chen's chirp.

Usage

```
data(ch)
```

Format

A vector containing 15,000 observations.

Source

See discussions in the text of "Practical Time-Frequency Analysis".

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(ch)
plot.ts(ch)
```

check.maxresoln *Verify Maximum Resolution*

Description

Stop when $2^{maxresoln}$ is larger than the signal size.

Usage

```
check.maxresoln(maxresoln, np)
```

Arguments

`maxresoln`	number of decomposition scales.
`np`	signal size.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`mw`, `mrecons`.

chirpm5db.dat *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(chirpm5db.dat)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
## Not run:
data(chirpm5db.dat)


## End(Not run)
```

`cleanph` *Threshold Phase based on Modulus*

Description

Sets to zero the phase of time-frequency transform when modulus is below a certain value.

Usage

```
cleanph(tfrep, thresh=0.01, plot=TRUE)
```

Arguments

`tfrep`	continuous time-frequency transform (2D array)
`thresh`	(relative) threshold.
`plot`	if set to TRUE, displays the maxima of cwt on the graphic device.

Value

thresholded phase (2D array)

References

See discussion in text of “Practical Time-Frequency Analysis”.

`click` *Dolphin Click Data*

Description

Dolphin click data.

Usage

```
data(click)
```

Format

A vector containing 2499 observations.

Source

See discussions in the text of "Practical Time-Frequency Analysis".

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(click)
plot.ts(click)
```

`click.asc` *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(click.asc)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(click.asc)
plot.ts(click.asc)
```

---

corona *Ridge Estimation by Corona Method*

Description

Estimate a (single) ridge from a time-frequency representation, using the corona method.

Usage

```
corona(tfrep, guess, tfspec=numeric(dim(tfrep)[2]), subrate=1,
temprate=3, mu=1, lambda=2 * mu, iteration=1000000, seed=-7,
stagnant=20000, costsub=1, plot=TRUE)
```

Arguments

`tfrep`	Time-Frequency representation (real valued).
`guess`	Initial guess for the algorithm.
`tfspec`	Estimate for the contribution of the noise to modulus.
`subrate`	Subsampling rate for ridge estimation.
`temprate`	Initial value of temperature parameter.
`mu`	Coefficient of the ridge’s second derivative in cost function.
`lambda`	Coefficient of the ridge’s derivative in cost function.
`iteration`	Maximal number of moves.
`seed`	Initialization of random number generator.
`stagnant`	Maximum number of stationary iterations before stopping.
`costsub`	Subsampling of cost function in output.
`plot`	When set(default), some results will be shown on the display.

Details

To accelerate convergence, it is useful to preprocess modulus before running annealing method. Such a preprocessing (smoothing and subsampling of modulus) is implemented in `corona`. The parameter subrate specifies the subsampling rate.

Value

Returns the estimated ridge and the cost function.

`ridge`	1D array (of same length as the signal) containing the ridge.
`cost`	1D array containing the cost function.

Warning

The returned cost may be a large array, which is time consuming. The argument costsub allows subsampling the cost function.

References

See discussion in text of "Practical Time-Frequency Analysis".

See Also

`icm`,`coronoid`,`snake`, `snakoid`.

`coronoid` *Ridge Estimation by Modified Corona Method*

Description

Estimate a ridge using the modified corona method (modified cost function).

Usage

```
coronoid(tfrep, guess, tfspec=numeric(dim(tfrep)[2]), subrate=1,
temprate=3, mu=1, lambda=2 * mu, iteration=1000000, seed=-7,
stagnant=20000, costsub=1, plot=TRUE)
```

Arguments

`tfrep`	Estimate for the contribution of the noise to modulus.
`guess`	Initial guess for the algorithm.
`tfspec`	Estimate for the contribution of the noise to modulus.
`subrate`	Subsampling rate for ridge estimation.
`temprate`	Initial value of temperature parameter.
`mu`	Coefficient of the ridge's derivative in cost function.

lambda	Coefficient of the ridge's second derivative in cost function.
iteration	Maximal number of moves.
seed	Initialization of random number generator.
stagnant	Maximum number of stationary iterations before stopping.
costsub	Subsampling of cost function in output.
plot	When set(default), some results will be shown on the display.

Details

To accelerate convergence, it is useful to preprocess modulus before running annealing method. Such a preprocessing (smoothing and subsampling of modulus) is implemented in `coronoid`. The parameter subrate specifies the subsampling rate.

Value

Returns the estimated ridge and the cost function.

ridge	1D array (of same length as the signal) containing the ridge.
cost	1D array containing the cost function.

Warning

The returned cost may be a large array. The argument costsub allows subsampling the cost function.

References

See discussion in text of "Practical Time-Frequency Analysis".

See Also

`corona`, `icm`, `snake`, `snakoid`.

---

crc — *Ridge Extraction by Crazy Climbers*

Description

Uses the "crazy climber algorithm" to detect ridges in the modulus of a continuous wavelet or a Gabor transform.

Usage

```
crc(tfrep, tfspec=numeric(dim(tfrep)[2]), bstep=3, iteration=10000,
rate=0.001, seed=-7, nbclimb=10, flag.int=TRUE, chain=TRUE,
flag.temp=FALSE)
```

Arguments

tfrep	modulus of the (wavelet or Gabor) transform.
tfspec	numeric vector which gives, for each value of the scale or frequency the expected size of the noise contribution.
bstep	stepsize for random walk of the climbers.
iteration	number of iterations.
rate	initial value of the temperature.
seed	initial value of the random number generator.
nbclimb	number of crazy climbers.
flag.int	if set to TRUE, the weighted occupation measure is computed.
chain	if set to TRUE, chaining of the ridges is done.
flag.temp	if set to TRUE: constant temperature.

Value

Returns a 2D array called beemap containing the (weighted or unweighted) occupation measure (integrated with respect to time)

References

See discussion in text of "Practical Time-Frequency Analysis".

See Also

corona, icm, coronoid, snake, snakoid for ridge estimation, cfamily for chaining and crcrec,gcrcrec,scrcrec for reconstruction.

Examples

```
   data(HOWAREYOU)
 plot.ts(HOWAREYOU)

cgtHOWAREYOU <- cgt(HOWAREYOU,70,0.01,100)

clHOWAREYOU <- crc(Mod(cgtHOWAREYOU),nbclimb=1000)
```

crcrec *Crazy Climbers Reconstruction by Penalization*

Description

Reconstructs a real valued signal from the output of crc (wavelet case) by minimizing an appropriate quadratic form.

Usage

```
crcrec(siginput, inputwt, beemap, noct, nvoice, compr, minnbnodes=2,
w0=2 * pi, bstep=5, ptile=0.01, epsilon=0, fast=FALSE, para=5, real=FALSE,
plot=2)
```

Arguments

siginput	original signal.
inputwt	wavelet transform.
beemap	occupation measure, output of crc.
noct	number of octaves.
nvoice	number of voices per octave.
compr	compression rate for sampling the ridges.
minnbnodes	minimal number of points per ridge.
w0	center frequency of the wavelet.
bstep	size (in the time direction) of the steps for chaining.
ptile	relative threshold of occupation measure.
epsilon	constant in front of the smoothness term in penalty function.
fast	if set to TRUE, uses trapezoidal rule to evaluate Q_2.
para	scale parameter for extrapolating the ridges.
real	if set to TRUE, uses only real constraints.
plot	1: displays signal,components,and reconstruction one after another. 2: displays signal, components and reconstruction.

Details

When ptile is high, boundary effects may appeare. para controls extrapolation of the ridge.

Value

Returns a structure containing the following elements:

rec	reconstructed signal.
ordered	image of the ridges (with different colors).
comp	2D array containing the signals reconstructed from ridges.

See Also

`crc`, `cfamily`, `scrcrec`.

`crfview` *Display chained ridges*

Description

displays a family of chained ridges, output of `cfamily`.

Usage

```
crfview(beemap, twod=TRUE)
```

Arguments

beemap	Family of chained ridges, output of `cfamily`.
twod	If set to T, displays the ridges as an image. If set to F, displays as a series of curves.

References

See discussions in the text of "Practical Time-Frequency Analysis".

See Also

`crc`,`cfamily` for crazy climbers and corresponding chaining algorithms.

`cwt` *Continuous Wavelet Transform*

Description

Computes the continuous wavelet transform with for the (complex-valued) Morlet wavelet.

Usage

```
cwt(input, noctave, nvoice=1, w0=2 * pi, twoD=TRUE, plot=TRUE)
```

Arguments

`input`	input signal (possibly complex-valued)
`noctave`	number of powers of 2 for the scale variable
`nvoice`	number of scales in each octave (i.e. between two consecutive powers of 2).
`w0`	central frequency of the wavelet.
`twoD`	logical variable set to T to organize the output as a 2D array (signal_size x nb_scales), otherwise, the output is a 3D array (signal_size x noctave x nvoice).
`plot`	if set to T, display the modulus of the continuous wavelet transform on the graphic device.

Details

The output contains the (complex) values of the wavelet transform of the input signal. The format of the output can be

2D array (signal_size x nb_scales)

3D array (signal_size x noctave x nvoice)

Since Morlet's wavelet is not strictly speaking a wavelet (it is not of vanishing integral), artifacts may occur for certain signals.

Value

continuous (complex) wavelet transform

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`cwtp`, `cwtTh`, `DOG`, `gabor`.

Examples

```
x <- 1:512
chirp <- sin(2*pi * (x + 0.002 * (x-256)^2 ) / 16)
retChirp <- cwt(chirp, noctave=5, nvoice=12)
```

cwtimage — *Continuous Wavelet Transform Display*

Description

Converts the output (modulus or argument) of cwtpolar to a 2D array and displays on the graphic device.

Usage

```
cwtimage(input)
```

Arguments

`input`	3D array containing a continuous wavelet transform

Details

The output contains the (complex) values of the wavelet transform of the input signal. The format of the output can be

2D array (signal_size x nb_scales)

3D array (signal_size x noctave x nvoice)

Value

2D array continuous (complex) wavelet transform

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`cwtpolar`, `cwt`, `DOG`.

Examples

```
x <- 1:512
chirp <- sin(2*pi * (x + 0.002 * (x-256)^2 ) / 16)
retChirp <- cwt(chirp, noctave=5, nvoice=12, twoD=FALSE, plot=FALSE)
retPolar <- cwtpolar(retChirp)
retImageMod <- cwtimage(retPolar$modulus)
retImageArg <- cwtimage(retPolar$argument)
```

cwtp *Continuous Wavelet Transform with Phase Derivative*

Description

Computes the continuous wavelet transform with (complex-valued) Morlet wavelet and its phase derivative.

Usage

```
cwtp(input, noctave, nvoice=1, w0=2 * pi, twoD=TRUE, plot=TRUE)
```

Arguments

`input`	input signal (possibly complex-valued)
`noctave`	number of powers of 2 for the scale variable
`nvoice`	number of scales in each octave (i.e., between two consecutive powers of 2).
`w0`	central frequency of the wavelet.
`twoD`	logical variable set to `T` to organize the output as a 2D array (signal size $\times$ nb scales), otherwise, the output is a 3D array (signal size $\times$ noctave $\times$ nvoice).
`plot`	if set to `TRUE`, display the modulus of the continuous wavelet transform on the graphic device.

Value

list containing the continuous (complex) wavelet transform and the phase derivative

`wt`	array of complex numbers for the values of the continuous wavelet transform.
`f`	array of the same dimensions containing the values of the derivative of the phase of the continuous wavelet transform.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`cgt`, `cwt`, `cwtTh`, `DOG` for wavelet transform, and `gabor` for continuous Gabor transform.

Examples

```
## discards imaginary part with error,
## c code does not account for Im(input)
x <- 1:512
chirp <- sin(2*pi * (x + 0.002 * (x-256)^2 ) / 16)
chirp <- chirp + 1i * sin(2*pi * (x + 0.004 * (x-256)^2 ) / 16)
retChirp <- cwtp(chirp, noctave=5, nvoice=12)
```

`cwtpolar` *Conversion to Polar Coordinates*

Description

Converts one of the possible outputs of the function `cwt` to modulus and phase.

Usage

```
cwtpolar(cwt, threshold=0)
```

Arguments

`cwt`	3D array containing the values of a continuous wavelet transform in the format (signal size $\times$ noctave $\times$ nvoice) as in the output of the function `cwt` with the logical flag `twodimension` set to FALSE.
`threshold`	value of a level for the absolute value of the modulus below which the value of the argument of the output is set to $-\pi$.

Details

The output contains the (complex) values of the wavelet transform of the input signal. The format of the output can be

2D array (signal size $\times$ nb_scales)

3D array (signal size $\times$ noctave $\times$ nvoice)

Value

Modulus and Argument of the values of the continuous wavelet transform

`output1`	3D array giving the values (in the same format as the input) of the modulus of the input.
`output2`	3D array giving the values of the argument of the input.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`cwt`, `DOG`, `cwtimage`.

Examples

```
x <- 1:512
chirp <- sin(2*pi * (x + 0.002 * (x-256)^2 ) / 16)
retChirp <- cwt(chirp, noctave=5, nvoice=12, twoD=FALSE, plot=FALSE)
retPolar <- cwtpolar(retChirp)
```

cwtsquiz *Squeezed Continuous Wavelet Transform*

Description

Computes the synchrosqueezed continuous wavelet transform with the (complex-valued) Morlet wavelet.

Usage

```
cwtsquiz(input, noctave, nvoice=1, w0=2 * pi, twoD=TRUE, plot=TRUE)
```

Arguments

`input`	input signal (possibly complex-valued)
`noctave`	number of powers of 2 for the scale variable
`nvoice`	number of scales in each octave (i.e. between two consecutive powers of 2).
`w0`	central frequency of the wavelet.
`twoD`	logical variable set to T to organize the output as a 2D array (signal size $\times$ nb scales), otherwise, the output is a 3D array (signal size $\times$ noctave $\times$ nvoice).
`plot`	logical variable set to T to T to display the modulus of the squeezed wavelet transform on the graphic device.

Details

The output contains the (complex) values of the squeezed wavelet transform of the input signal. The format of the output can be

2D array (signal size $\times$ nb scales),

3D array (signal size $\times$ noctave $\times$ nvoice).

Value

synchrosqueezed continuous (complex) wavelet transform

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`cwt`, `cwtp`, `DOG`, `cgt`.

`cwtTh` *Cauchy's wavelet transform*

Description

Compute the continuous wavelet transform with (complex-valued) Cauchy's wavelet.

Usage

```
cwtTh(input, noctave, nvoice=1, moments, twoD=TRUE, plot=TRUE)
```

Arguments

`input`	input signal (possibly complex-valued).
`noctave`	number of powers of 2 for the scale variable.
`nvoice`	number of scales in each octave (i.e. between two consecutive powers of 2).
`moments`	number of vanishing moments.
`twoD`	logical variable set to `T` to organize the output as a 2D array (signal size x nb scales), otherwise, the output is a 3D array (signal size x noctave x nvoice).
`plot`	if set to `T`, display the modulus of the continuous wavelet transform on the graphic device.

Details

The output contains the (complex) values of the wavelet transform of the input signal. The format of the output can be

2D array (signal size $\times$ nb scales)

3D array (signal size $\times$ noctave $\times$ nvoice)

Value

`tmp`	continuous (complex) wavelet transform.

References

See discussions in the text of "Practical Time-Frequency Analysis".

See Also

`cwt`, `cwtp`, `DOG`, `gabor`.

Examples

```
x <- 1:512
chirp <- sin(2*pi * (x + 0.002 * (x-256)^2 ) / 16)
retChirp <- cwtTh(chirp, noctave=5, nvoice=12, moments=20)
```

D0 *Transient Signal*

Description

Transient signal.

Usage

```
data(D0)
```

Format

A vector containing 1024 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(D0)
plot.ts(D0)
```

D4 *Transient Signal*

Description

Transient signal.

Usage

```
data(D4)
```

Format

A vector containing 1024 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(D4)
plot.ts(D4)
```

DOG *Continuous Wavelet Transform with derivative of Gaussian*

Description

Computes the continuous wavelet transform with for (complex-valued) derivative of Gaussian wavelets.

Usage

```
DOG(input, noctave, nvoice=1, moments, twoD=TRUE, plot=TRUE)
```

Arguments

`input`	input signal (possibly complex-valued).
`noctave`	number of powers of 2 for the scale variable.
`moments`	number of vanishing moments of the wavelet (order of the derivative).
`nvoice`	number of scales in each octave (i.e. between two consecutive powers of 2)
`twoD`	logical variable set to T to organize the output as a 2D array (signal_size x nb_scales), otherwise, the output is a 3D array (signal_size x noctave x nvoice)
`plot`	if set to T, display the modulus of the continuous wavelet transform on the graphic device

Details

The output contains the (complex) values of the wavelet transform of the input signal. The format of the output can be

2D array (signal_size x nb_scales)

3D array (signal_size x noctave x nvoice)

Value

continuous (complex) wavelet transform

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

cwt, cwtp, cwtsquiz, cgt.

Examples

```
x <- 1:512
   chirp <- sin(2*pi * (x + 0.002 * (x-256)^2 ) / 16)

DOG(chirp, noctave=5, nvoice=12, 3, twoD=TRUE, plot=TRUE)
```

---

dwinverse *Inverse Dyadic Wavelet Transform*

Description

Invert the dyadic wavelet transform.

Usage

```
dwinverse(wt, filtername="Gaussian1")
```

Arguments

wt	dyadic wavelet transform
filtername	filters used. ("Gaussian1" stands for the filters corresponds to those of Mallat and Zhong's wavlet. And "Haar" stands for the filters of Haar basis.

Value

Reconstructed signal

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

mw, ext, mrecons.

Ekg — *Heart Rate Data*

Description

Successive beat-to-beat intervals for a normal patient.

Usage

```
data(Ekg)
```

Format

A vector containing 16,042 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(Ekg)
plot.ts(Ekg)
```

epl — *Plot Dyadic Wavelet Transform Extrema*

Description

Plot dyadic wavelet transform extrema (output of `ext`).

Usage

```
epl(dwext)
```

Arguments

`dwext`	dyadic wavelet transform (output of `ext`).

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

mw, ext, wpl.

---

ext *Extrema of Dyadic Wavelet Transform*

Description

Compute the local extrema of the dyadic wavelet transform modulus.

Usage

```
ext(wt, scale=FALSE, plot=TRUE)
```

Arguments

wt	dyadic wavelet transform.
scale	flag indicating if the extrema at each resolution will be plotted at the same scale.
plot	if set to TRUE, displays the transform on the graphics device.

Value

Structure containing:

original	original signal.
extrema	extrema representation.
Sf	coarse resolution of signal.
maxresoln	number of decomposition scales.
np	size of signal.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

mw, mrecons.

fastgkernel *Kernel for Reconstruction from Gabor Ridges*

Description

Computes the cost from the sample of points on the estimated ridge and the matrix used in the reconstruction of the original signal, using simple trapezoidal rule for integrals.

Usage

```
fastgkernel(node, phinode, freqstep, scale, x.inc=1, x.min=node[1],
x.max=node[length(node)], plot=FALSE)
```

Arguments

node	values of the variable b for the nodes of the ridge
phinode	values of the frequency variable ω for the nodes of the ridge
freqstep	sampling rate for the frequency axis
scale	size of the window
x.inc	step unit for the computation of the kernel.
x.min	minimal value of x for the computation of G_2.
x.max	maximal value of x for the computation of G_2.
plot	if set to TRUE, displays the modulus of the matrix of G_2.

Details

Uses trapezoidal rule (instead of Romberg's method) to evaluate the kernel.

Value

matrix of the G_2 kernel.

References

See discussions in the text of "Time-Frequency Analysis".

See Also

gkernel, fastkernel, rkernel, zerokernel.

fastkernel *Kernel for Reconstruction from Wavelet Ridges*

Description

Computes the cost from the sample of points on the estimated ridge and the matrix used in the reconstruction of the original signal, using simple trapezoidal rule for integrals.

Usage

```
fastkernel(node, phinode, nvoice, x.inc=1, x.min=node[1],
x.max=node[length(node)], w0=2 * pi, plot=FALSE)
```

Arguments

node	values of the variable b for the nodes of the ridge.
phinode	values of the scale variable a for the nodes of the ridge.
nvoice	number of scales within 1 octave.
x.inc	step unit for the computation of the kernel
x.min	minimal value of x for the computation of Q_2.
x.max	maximal value of x for the computation of Q_2.
w0	central frequency of the wavelet
plot	if set to TRUE, displays the modulus of the matrix of Q_2.

Details

Uses trapezoidal rule (instead of Romberg's method) to evaluate the kernel.

Value

matrix of the Q_2 kernel.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

kernel, rkernel, gkernel, zerokernel.

gabor — *Generate Gabor function*

Description

Generates a Gabor for given location and frequency.

Usage

```
gabor(sigsize, location, frequency, scale)
```

Arguments

`sigsize`	length of the Gabor function.
`location`	position of the Gabor function.
`frequency`	frequency of the Gabor function.
`scale`	size parameter for the Gabor function. See details.

Details

The size parameter here corresponds to the standard deviation for a gaussian. In the Carmona (1998, eBook ISBN:978008053942) book, equation 3.23 has a different scale factor.

Value

complex 1D array of size sigsize.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`morlet`.

Examples

```
m1 = gabor(1024, 512,  2 * pi, 20 )

plot.ts(Re(m1) )
```

gcrcrec *Crazy Climbers Reconstruction by Penalization*

Description

Reconstructs a real-valued signal from ridges found by crazy climbers on a Gabor transform.

Usage

```
gcrcrec(siginput, inputgt, beemap, nvoice, freqstep, scale, compr,
        bstep=5, ptile=0.01, epsilon=0, fast=TRUE, para=5, minnbnodes=3,
        hflag=FALSE, real=FALSE, plot=2)
```

Arguments

`siginput`	original signal.
`inputgt`	Gabor transform.
`beemap`	occupation measure, output of `crc`.
`nvoice`	number of frequencies.
`freqstep`	sampling step for frequency axis.
`scale`	size of windows.
`compr`	compression rate to be applied to the ridges.
`bstep`	size (in the time direction) of the steps for chaining.
`ptile`	threshold of ridge
`epsilon`	constant in front of the smoothness term in penalty function.
`fast`	if set to TRUE, uses trapezoidal rule to evaluate Q_2.
`para`	scale parameter for extrapolating the ridges.
`minnbnodes`	minimal number of points per ridge.
`hflag`	if set to FALSE, uses the identity as first term in the kernel. If not, uses Q_1 instead.
`real`	if set to `TRUE`, uses only real constraints.
`plot`	**1** displays signal,components, and reconstruction one after another. **2** displays signal, components and reconstruction.

Details

When `ptile` is high, boundary effects may appear. `para` controls extrapolation of the ridge.

Value

Returns a structure containing the following elements:

`rec`	reconstructed signal.
`ordered`	image of the ridges (with different colors).
`comp`	2D array containing the signals reconstructed from ridges.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`crc`, `cfamily`, `crcrec`, `scrcrec`.

`gkernel` *Kernel for Reconstruction from Gabor Ridges*

Description

Computes the cost from the sample of points on the estimated ridge and the matrix used in the reconstruction of the original signal.

Usage

```
gkernel(node, phinode, freqstep, scale, x.inc=1, x.min=node[1],
x.max=node[length(node)], plot=FALSE)
```

Arguments

`node`	values of the variable b for the nodes of the ridge.
`phinode`	values of the scale variable a for the nodes of the ridge.
`freqstep`	sampling rate for the frequency axis.
`scale`	size of the window.
`x.inc`	step unit for the computation of the kernel.
`x.min`	minimal value of x for the computation of Q_2.
`x.max`	maximal value of x for the computation of Q_2.
`plot`	if set to TRUE, displays the modulus of the matrix of Q_2.

Value

matrix of the Q_2 kernel

References

See discussions in the text of “Time-Frequency Analysis”.

See Also

`fastgkernel`, `kernel`, `rkernel`, `fastkernel`, `zerokernel`.

gregrec *Reconstruction from a Ridge*

Description

Reconstructs signal from a “regularly sampled” ridge, in the Gabor case.

Usage

```
gregrec(siginput, gtinput, phi, nbnodes, nvoice, freqstep, scale,
epsilon=0, fast=FALSE, plot=FALSE, para=0, hflag=FALSE, real=FALSE,
check=FALSE)
```

Arguments

`siginput`	input signal.
`gtinput`	Gabor transform, output of `cgt`.
`phi`	unsampled ridge.
`nbnodes`	number of nodes used for the reconstruction.
`nvoice`	number of different scales per octave
`freqstep`	sampling rate for the frequency axis
`scale`	size parameter for the Gabor function.
`epsilon`	coefficient of the Q_2 term in reconstruction kernel
`fast`	if set to T, the kernel is computed using trapezoidal rule.
`plot`	if set to TRUE, displays original and reconstructed signals
`para`	scale parameter for extrapolating the ridges.
`hflag`	if set to TRUE, uses Q_1 as first term in the kernel.
`real`	if set to TRUE, uses only real constraints on the transform.
`check`	if set to TRUE, computes `cwt` of reconstructed signal.

Value

Returns a list containing:

`sol`	reconstruction from a ridge.
`A`	<gaborlets,dualgaborlets> matrix.
`lam`	coefficients of dual wavelets in reconstructed signal.
`dualwave`	array containing the dual wavelets.
`gaborets`	array containing the wavelets on sampled ridge.
`solskel`	Gabor transform of sol, restricted to the ridge.
`inputskel`	Gabor transform of signal, restricted to the ridge.
`Q2`	second part of the reconstruction kernel.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

regrec.

---

gridrec *Reconstruction from a Ridge*

Description

Reconstructs signal from sample of a ridge, in the Gabor case.

Usage

```
gridrec(gtinput, node, phinode, nvoice, freqstep, scale, Qinv,
epsilon, np, real=FALSE, check=FALSE)
```

Arguments

gtinput	Gabor transform, output of cgt.
node	time coordinates of the ridge samples.
phinode	frequency coordinates of the ridge samples.
nvoice	number of different frequencies.
freqstep	sampling rate for the frequency axis.
scale	scale of the window.
Qinv	inverse of the matrix Q of the quadratic form.
epsilon	coefficient of the Q_2 term in reconstruction kernel
np	number of samples of the reconstructed signal.
real	if set to TRUE, uses only constraints on the real part of the transform.
check	if set to TRUE, computes cgt of reconstructed signal.

Value

Returns a list containing the reconstructed signal and the chained ridges.

sol	reconstruction from a ridge.
A	<gaborlets,dualgaborlets> matrix.
lam	coefficients of dual gaborlets in reconstructed signal.
dualwave	array containing the dual gaborlets.
gaborets	array of gaborlets located on the ridge samples.
solskel	Gabor transform of sol, restricted to the ridge.
inputskel	Gabor transform of signal, restricted to the ridge.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`sridrec`, `gregrec`, `regrec`, `regrec2`.

---

gsampleOne — *Sampled Identity*

Description

Generate a sampled identity matrix.

Usage

```
gsampleOne(node, scale, np)
```

Arguments

`node`	location of the reconstruction gabor functions.
`scale`	scale of the gabor functions.
`np`	size of the reconstructed signal.

Value

diagonal of the “sampled” Q_1 term (1D vector)

References

See discussions in the text of “Time-Frequency Analysis”.

See Also

`kernel`, `gkernel`.

gwave *Gabor Functions on a Ridge*

Description

Generation of Gabor functions located on the ridge.

Usage

```
gwave(bridge, omegaridge, nvoice, freqstep, scale, np, N)
```

Arguments

bridge	time coordinates of the ridge samples
omegaridge	frequency coordinates of the ridge samples
nvoice	number of different scales per octave
freqstep	sampling rate for the frequency axis
scale	scale of the window
np	size of the reconstruction kernel
N	number of complex constraints

Value

Array of Gabor functions located on the ridge samples

References

See discussions in the text of "Time-Frequency Analysis".

See Also

gwave2, morwave, morwave2.

gwave2 *Real Gabor Functions on a Ridge*

Description

Generation of the real parts of gabor functions located on a ridge. (modification of gwave.)

Usage

```
gwave2(bridge, omegaridge, nvoice, freqstep, scale, np, N)
```

Arguments

`bridge`	time coordinates of the ridge samples
`omegaridge`	frequency coordinates of the ridge samples
`nvoice`	number of different scales per octave
`freqstep`	sampling rate for the frequency axis
`scale`	scale of the window
`np`	size of the reconstruction kernel
`N`	number of complex constraints

Value

Array of real Gabor functions located on the ridge samples

References

See discussions in the text of “Time-Frequency Analysis”.

See Also

`gwave`, `morwave`, `morwave2`.

HeartRate *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(HeartRate)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942), eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(HeartRate)
plot.ts(HeartRate)
```

HOWAREYOU *How Are You?*

Description

Example of speech signal.

Usage

```
data(HOWAREYOU)
```

Format

A vector containing 5151 observations.

Source

See discussions in the text of "Practical Time-Frequency Analysis".

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(HOWAREYOU)
plot.ts(HOWAREYOU)
```

hurst.est *Estimate Hurst Exponent*

Description

Estimates Hurst exponent from a wavelet transform.

Usage

```
hurst.est(wspec, range, nvoice, plot=TRUE)
```

Arguments

wspec	wavelet spectrum (output of tfmean)
range	range of scales from which estimate the exponent.
nvoice	number of scales per octave of the wavelet transform.
plot	if set to TRUE, displays regression line on current plot.

Value

complex 1D array of size sigsize.

References

See discussions in the text of "Practical Time-Frequency Analysis".

See Also

tfmean, wspec.pl.

Examples

```
# White Noise Hurst Exponent: The plots on the top row of Figure 6.8
# were produced by the folling S-commands. These make use of the two
# functions Hurst.est (estimation of Hurst exponent from CWT) and
# wspec.pl (display wavelet spectrum).

# Compare the periodogram and the wavelet spectral estimate.
wnoise <- rnorm(8192)
plot.ts(wnoise)
spwnoise <- fft(wnoise)
spwnoise <- Mod(spwnoise)
spwnoise <- spwnoise*spwnoise
plot(spwnoise[1:4096], log="xy", type="l")
lswnoise <- lsfit(log10(1:4096), log10(spwnoise[1:4096]))
abline(lswnoise$coef)
cwtwnoise <- DOG(wnoise, 10, 5, 1, plot=FALSE)
mcwtwnoise <- Mod(cwtwnoise)
```

```
mcwtwnoise <- mcwtwnoise*mcwtwnoise
wspwnoise <- tfmean(mcwtwnoise, plot=FALSE)
wspec.pl(wspwnoise, 5)
hurst.est(wspwnoise, 1:50, 5)
```

---

icm *Ridge Estimation by ICM Method*

Description

Estimate a (single) ridge from a time-frequency representation, using the ICM minimization method.

Usage

```
icm(modulus, guess, tfspec=numeric(dim(modulus)[2]), subrate=1,
mu=1, lambda=2 * mu, iteration=100)
```

Arguments

modulus	Time-Frequency representation (real valued).
guess	Initial guess for the algorithm.
tfspec	Estimate for the contribution of the noise to modulus.
subrate	Subsampling rate for ridge estimation.
mu	Coefficient of the ridge's second derivative in cost function.
lambda	Coefficient of the ridge's derivative in cost function.
iteration	Maximal number of moves.

Details

To accelerate convergence, it is useful to preprocess modulus before running annealing method. Such a preprocessing (smoothing and subsampling of modulus) is implemented in `icm`. The parameter subrate specifies the subsampling rate.

Value

Returns the estimated ridge and the cost function.

ridge	1D array (of same length as the signal) containing the ridge.
cost	1D array containing the cost function.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`corona`, `coronoid`, and `snake`, `snakoid`.

`mbtrim` *Trim Dyadic Wavelet Transform Extrema*

Description

Trimming of dyadic wavelet transform local extrema, using bootstrapping.

Usage

```
mbtrim(extrema, scale=FALSE, prct=0.95)
```

Arguments

`extrema`	dyadic wavelet transform extrema (output of `ext`).
`scale`	when set, the wavelet transform at each scale will be plotted with the same scale.
`prct`	percentage critical value used for thresholding

Details

The distribution of extrema of dyadic wavelet transform at each scale is generated by bootstrap method, and the 95% critical value is used for thresholding the extrema of the signal.

Value

Structure containing

`original`	original signal.
`extrema`	trimmed extrema representation.
`Sf`	coarse resolution of signal.
`maxresoln`	number of decomposition scales.
`np`	size of signal.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`mntrim`, `mrecons`, `ext`.

mntrim *Trim Dyadic Wavelet Transform Extrema*

Description

Trimming of dyadic wavelet transform local extrema, assuming normal distribution.

Usage

```
mntrim(extrema, scale=FALSE, prct=0.95)
```

Arguments

extrema	dyadic wavelet transform extrema (output of ext).
scale	when set, the wavelet transform at each scale will be plotted with the same scale.
prct	percentage critical value used for thresholding

Details

The distribution of extrema of dyadic wavelet transform at each scale is generated by simulation, assuming a normal distribution, and the 95% critical value is used for thresholding the extrema of the signal.

Value

Structure containing

original	original signal.
extrema	trimmed extrema representation.
Sf	coarse resolution of signal.
maxresoln	number of decomposition scales.
np	size of signal.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

mbtrim, mrecons, ext.

`morlet` *Morlet Wavelets*

Description

Computes a Morlet wavelet at the point of the time-scale plane given in the input

Usage

```
morlet(sigsize, location, scale, w0=2 * pi)
```

Arguments

`sigsize`	length of the output.
`location`	time location of the wavelet.
`scale`	scale of the wavelet.
`w0`	central frequency of the wavelet.

Details

The details of this construction (including the definition formulas) are given in the text.

Value

Returns the values of the complex Morlet wavelet at the point of the time-scale plane given in the input

References

See discussions in the text of "Practical Time-Frequency Analysis".

See Also

`gabor`.

Examples

```
m1 = morlet(1024, 512, 20, w0=2 * pi)
plot.ts(Re(m1) )
```

morwave — *Ridge Morvelets*

Description

Generates the Morlet wavelets at the sample points of the ridge.

Usage

```
morwave(bridge, aridge, nvoice, np, N, w0=2 * pi)
```

Arguments

bridge	time coordinates of the ridge samples.
aridge	scale coordinates of the ridge samples.
nvoice	number of different scales per octave.
np	number of samples in the input signal.
N	size of reconstructed signal.
w0	central frequency of the wavelet.

Value

Returns the Morlet wavelets at the samples of the time-scale plane given in the input: complex array of Morlet wavelets located on the ridge samples

References

See discussions in the text of “Time-Frequency Analysis”.

See Also

morwave2, gwave, gwave2.

morwave2 — *Real Ridge Morvelets*

Description

Generates the real parts of the Morlet wavelets at the sample points of a ridge

Usage

```
morwave2(bridge, aridge, nvoice, np, N, w0=2 * pi)
```

Arguments

`bridge`	time coordinates of the ridge samples.
`aridge`	scale coordinates of the ridge samples.
`nvoice`	number of different scales per octave.
`np`	number of samples in the input signal.
`N`	size of reconstructed signal.
`w0`	central frequency of the wavelet.

Value

Returns the real parts of the Morlet wavelets at the samples of the time-scale plane given in the input: array of Morlet wavelets located on the ridge samples

References

See discussions in the text of "Time-Frequency Analysis".

See Also

`morwave`, `gwave`, `gwave2`.

`mrecons` *Reconstruct from Dyadic Wavelet Transform Extrema*

Description

Reconstruct from dyadic wavelet transform modulus extrema. The reconstructed signal preserves locations and values at extrema.

Usage

```
mrecons(extrema, filtername="Gaussian1", readflag=FALSE)
```

Arguments

`extrema`	the extrema representation.
`filtername`	filter used for dyadic wavelet transform.
`readflag`	if set to T, read reconstruction kernel from precomputed file.

Details

The reconstruction involves only the wavelet coefficients, without taking care of the coarse scale component. The latter may be added a posteriori.

Value

Structure containing

`f`	the reconstructed signal.
`g`	reconstructed signal plus mean of original signal.
`h`	reconstructed signal plus coarse scale component of original signal.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`mw`, `ext`.

---

mw — *Dyadic Wavelet Transform*

Description

Dyadic wavelet transform, with Mallat’s wavelet. The reconstructed signal preserves locations and values at extrema.

Usage

```
mw(inputdata, maxresoln, filtername="Gaussian1", scale=FALSE, plot=TRUE)
```

Arguments

`inputdata`	either a text file or an R object containing data.
`maxresoln`	number of decomposition scales.
`filtername`	name of filter (either Gaussian1 for Mallat and Zhong’s wavelet or Haar wavelet).
`scale`	when set, the wavelet transform at each scale is plotted with the same scale.
`plot`	indicate if the wavelet transform at each scale will be plotted.

Details

The decomposition goes from resolution 1 to the given maximum resolution.

Value

Structure containing

`original`	original signal.
`Wf`	dyadic wavelet transform of signal.
`Sf`	multiresolution of signal.
`maxresoln`	number of decomposition scales.
`np`	size of signal.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

dwinverse, mrecons, ext.

---

noisy.dat *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(noisy.dat)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(noisy.dat)
plot.ts(noisy.dat)
```

noisywave *Noisy Gravitational Wave*

Description

Noisy gravitational wave.

Usage

```
data(noisywave)
```

Format

A vector containing 8192 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(noisywave)
plot.ts(noisywave)
```

---

npl *Prepare Graphics Environment*

Description

Splits the graphics device into prescrivbed number of windows.

Usage

```
npl(nbrow)
```

Arguments

nbrow	number of plots.

pixel_8.7 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(pixel_8.7)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(pixel_8.7)
plot.ts(pixel_8.7)
```

pixel_8.8 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(pixel_8.8)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(pixel_8.8)
plot.ts(pixel_8.8)
```

`pixel_8.9` *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(pixel_8.9)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(pixel_8.9)
plot.ts(pixel_8.9)
```

plotResult — *Plot Dyadic Wavelet Transform Extrema*

Description

Plot extrema of dyadic wavelet transform.

Usage

```
plotResult(result, original, maxresoln, scale=FALSE, yaxtype="s")
```

Arguments

`result`	result.
`original`	input signal.
`maxresoln`	number of decomposition scales.
`scale`	when set, the extrema at each scale is plotted withe the same scale.
`yaxtype`	y axis type (see R manual).

References

See discussions in the text of "Time-Frequency Analysis".

See Also

`plotwt`, `epl`, `wpl`.

plotwt — *Plot Dyadic Wavelet Transform*

Description

Plot dyadic wavelet transform.

Usage

```
plotwt(original, psi, phi, maxresoln, scale=FALSE, yaxtype="s")
```

Arguments

`original`	input signal.
`psi`	dyadic wavelet transform.
`phi`	scaling function transform at last resolution.
`maxresoln`	number of decomposition scales.
`scale`	when set, the wavelet transform at each scale is plotted with the same scale.
`yaxtype`	axis type (see R manual).

References

See discussions in the text of "Time-Frequency Analysis".

See Also

plotResult, epl, wpl.

---

pure.dat *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(pure.dat)
```

Format

A vector containing observations.

Source

See discussions in the text of "Practical Time-Frequency Analysis".

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(pure.dat)
plot.ts(pure.dat)
```

purwave — *Pure Gravitational Wave*

Description

Pure gravitational wave.

Usage

```
data(purwave)
```

Format

A vector containing 8192 observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(purwave)
plot.ts(purwave)
```

regrec — *Reconstruction from a Ridge*

Description

Reconstructs signal from a “regularly sampled” ridge, in the wavelet case.

Usage

```
regrec(siginput, cwtinput, phi, compr, noct, nvoice, epsilon=0,
w0=2 * pi, fast=FALSE, plot=FALSE, para=0, hflag=FALSE,
check=FALSE, minnbnodes=2, real=FALSE)
```

Arguments

siginput	input signal.
cwtinput	wavelet transform, output of cwt.
phi	unsampled ridge.
compr	subsampling rate for the wavelet coefficients (at scale 1)
noct	number of octaves (powers of 2)
nvoice	number of different scales per octave
epsilon	coefficient of the Q_2 term in reconstruction kernel
w0	central frequency of Morlet wavelet
fast	if set to TRUE, the kernel is computed using trapezoidal rule.
plot	if set to TRUE, displays original and reconstructed signals
para	scale parameter for extrapolating the ridges.
hflag	if set to TRUE, uses Q_1 as first term in the kernel.
check	if set to TRUE, computes cwt of reconstructed signal.
minnbnodes	minimum number of nodes for the reconstruction.
real	if set to TRUE, uses only real constraints on the transform.

Value

Returns a list containing:

sol	reconstruction from a ridge.
A	<wavelets,dualwavelets> matrix.
lam	coefficients of dual wavelets in reconstructed signal.
dualwave	array containing the dual wavelets.
morvelets	array containing the wavelets on sampled ridge.
solskel	wavelet transform of sol, restricted to the ridge.
inputskel	wavelet transform of signal, restricted to the ridge.
Q2	second part of the reconstruction kernel.
nbnodes	number of nodes used for the reconstruction.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

regrec2, ridrec, gregrec, gridrec.

`regrec2` *Reconstruction from a Ridge*

Description

Reconstructs signal from a "regularly sampled" ridge, in the wavelet case, from a precomputed kernel.

Usage

```
regrec2(siginput, cwtinput, phi, nbnodes, noct, nvoice, Q2,
epsilon=0.5, w0=2 * pi, plot=FALSE)
```

Arguments

`siginput`	input signal.
`cwtinput`	wavelet transform, output of `cwt`.
`phi`	unsampled ridge.
`nbnodes`	number of samples on the ridge
`noct`	number of octaves (powers of 2)
`nvoice`	number of different scales per octave
`Q2`	second term of the reconstruction kernel
`epsilon`	coefficient of the Q_2 term in reconstruction kernel
`w0`	central frequency of Morlet wavelet
`plot`	if set to TRUE, displays original and reconstructed signals

Details

The computation of the kernel may be time consuming. This function avoids recomputing it if it was computed already.

Value

Returns a list containing:

`sol`	reconstruction from a ridge.
`A`	<wavelets,dualwavelets> matrix.
`lam`	coefficients of dual wavelets in reconstructed signal.
`dualwave`	array containing the dual wavelets.
`morvelets`	array containing the wavelets on sampled ridge.
`solskel`	wavelet transform of sol, restricted to the ridge.
`inputskel`	wavelet transform of signal, restricted to the ridge.
`nbnodes`	number of nodes used for the reconstruction.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

regrec, gregrec, ridrec, sridrec.

RidgeSampling *Sampling Gabor Ridge*

Description

Given a ridge phi (for the Gabor transform), returns a (regularly) subsampled version of length nbnodes.

Usage

```
RidgeSampling(phi, nbnodes)
```

Arguments

phi	ridge (1D array).
nbnodes	number of samples.

Details

Gabor ridges are sampled uniformly.

Value

Returns a list containing the discrete values of the ridge.

node	time coordinates of the ridge samples.
phinode	frequency coordinates of the ridge samples.

References

See discussions in the text of "Time-Frequency Analysis”.

See Also

wRidgeSampling.

ridrec *Reconstruction from a Ridge*

Description

Reconstructs signal from sample of a ridge, in the wavelet case.

Usage

```
ridrec(cwtinput, node, phinode, noct, nvoice, Qinv, epsilon, np,
w0=2 * pi, check=FALSE, real=FALSE)
```

Arguments

cwtinput	wavelet transform, output of cwt.
node	time coordinates of the ridge samples.
phinode	scale coordinates of the ridge samples.
noct	number of octaves (powers of 2).
nvoice	number of different scales per octave.
Qinv	inverse of the matrix Q of the quadratic form.
epsilon	coefficient of the Q_2 term in reconstruction kernel
np	number of samples of the reconstructed signal.
w0	central frequency of Morlet wavelet.
check	if set to TRUE, computes cwt of reconstructed signal.
real	if set to TRUE, uses only constraints on the real part of the transform.

Value

Returns a list containing the reconstructed signal and the chained ridges.

sol	reconstruction from a ridge
A	<wavelets,dualwavelets> matrix
lam	coefficients of dual wavelets in reconstructed signal.
dualwave	array containing the dual wavelets.
morvelets	array of morlet wavelets located on the ridge samples.
solskel	wavelet transform of sol, restricted to the ridge
inputskel	wavelet transform of signal, restricted to the ridge

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

sridrec, regrec, regrec2.

rkernel — *Kernel for Reconstruction from Wavelet Ridges*

Description

Computes the cost from the sample of points on the estimated ridge and the matrix used in the reconstruction of the original signal, in the case of real constraints. Modification of the function `kernel`.

Usage

```
rkernel(node, phinode, nvoice, x.inc=1, x.min=node[1],
x.max=node[length(node)], w0=2 * pi, plot=FALSE)
```

Arguments

`node`	values of the variable b for the nodes of the ridge.
`phinode`	values of the scale variable a for the nodes of the ridge.
`nvoice`	number of scales within 1 octave.
`x.inc`	step unit for the computation of the kernel.
`x.min`	minimal value of x for the computation of Q_2.
`x.max`	maximal value of x for the computation of Q_2.
`w0`	central frequency of the wavelet.
`plot`	if set to TRUE, displays the modulus of the matrix of Q_2.

Details

Uses Romberg's method for computing the kernel.

Value

matrix of the Q_2 kernel

References

See discussions in the text of "Time-Frequency Analysis".

See Also

`kernel`, `fastkernel`, `gkernel`, `zerokernel`.

rwkernel *Kernel for Reconstruction from Wavelet Ridges*

Description

Computes the cost from the sample of points on the estimated ridge and the matrix used in the reconstruction of the original signal

Usage

```
rwkernel(node, phinode, nvoice, x.inc=1, x.min=node[1],
x.max=node[length(node)], w0=2 * pi, plot=FALSE)
```

Arguments

node	values of the variable b for the nodes of the ridge.
phinode	values of the scale variable a for the nodes of the ridge.
nvoice	number of scales within 1 octave.
x.inc	step unit for the computation of the kernel.
x.min	minimal value of x for the computation of Q_2.
x.max	maximal value of x for the computation of Q_2.
w0	central frequency of the wavelet.
plot	if set to TRUE, displays the modulus of the matrix of Q_2.

Details

The kernel is evaluated using Romberg's method.

Value

matrix of the Q_2 kernel

References

See discussions in the text of "Time-Frequency Analysis".

See Also

gkernel, rkernel, zerokernel.

scrcrec — *Simple Reconstruction from Crazy Climbers Ridges*

Description

Reconstructs signal from ridges obtained by `crc`, using the restriction of the transform to the ridge.

Usage

```
scrcrec(siginput, tfinput, beemap, bstep=5, ptile=0.01, plot=2)
```

Arguments

`siginput`	input signal.
`tfinput`	time-frequency representation (output of `cwt` or `cgt`.
`beemap`	output of crazy climber algorithm
`bstep`	used for the chaining (see `cfamily`).
`ptile`	threshold on the measure beemap (see `cfamily`).
`plot`	1: displays signal,components, and reconstruction one after another. 2: displays signal, components and reconstruction. Else, no plot.

Value

Returns a list containing the reconstructed signal and the chained ridges.

`rec`	reconstructed signal
`ordered`	image of the ridges (with different colors)
`comp`	2D array containing the signals reconstructed from ridges

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`crc`,`cfamily` for crazy climbers method, `crcrec` for reconstruction methods.

signal_W_tilda.1 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(signal_W_tilda.1)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(signal_W_tilda.1)
plot.ts(signal_W_tilda.1)
```

signal_W_tilda.2 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(signal_W_tilda.2)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(signal_W_tilda.2)
plot.ts(signal_W_tilda.2)
```

`signal_W_tilda.3` *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(signal_W_tilda.3)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(signal_W_tilda.3)
plot.ts(signal_W_tilda.3)
```

signal_W_tilda.4 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(signal_W_tilda.4)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(signal_W_tilda.4)
plot.ts(signal_W_tilda.4)
```

signal_W_tilda.5 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(signal_W_tilda.5)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(signal_W_tilda.5)
plot.ts(signal_W_tilda.5)
```

`signal_W_tilda.6` *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(signal_W_tilda.6)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(signal_W_tilda.6)
plot.ts(signal_W_tilda.6)
```

`signal_W_tilda.7` *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(signal_W_tilda.7)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942), eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(signal_W_tilda.7)
plot.ts(signal_W_tilda.7)
```

`signal_W_tilda.8` *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(signal_W_tilda.8)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942), eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(signal_W_tilda.8)
plot.ts(signal_W_tilda.8)
```

---

signal_W_tilda.9 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(signal_W_tilda.9)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(signal_W_tilda.9)
plot.ts(signal_W_tilda.9)
```

sig_W_tilda.1 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(sig_W_tilda.1)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(sig_W_tilda.1)
plot.ts(sig_W_tilda.1)
```

sig_W_tilda.2 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(sig_W_tilda.2)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(sig_W_tilda.2)
plot.ts(sig_W_tilda.2)
```

---

sig_W_tilda.3 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(sig_W_tilda.3)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(sig_W_tilda.3)
plot.ts(sig_W_tilda.3)
```

sig_W_tilda.4 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(sig_W_tilda.4)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(sig_W_tilda.4)
plot.ts(sig_W_tilda.4)
```

sig_W_tilda.5 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(sig_W_tilda.5)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942), eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(sig_W_tilda.5)
plot.ts(sig_W_tilda.5)
```

---

skeleton *Reconstruction from Dual Wavelets*

Description

Computes the reconstructed signal from the ridge, given the inverse of the matrix Q.

Usage

```
skeleton(cwtinput, Qinv, morvelets, bridge, aridge, N)
```

Arguments

`cwtinput`	continuous wavelet transform (as the output of cwt)
`Qinv`	inverse of the reconstruction kernel (2D array)
`morvelets`	array of Morlet wavelets located at the ridge samples
`bridge`	time coordinates of the ridge samples
`aridge`	scale coordinates of the ridge samples
`N`	size of reconstructed signal

Value

Returns a list of the elements of the reconstruction of a signal from sample points of a ridge

`sol`	reconstruction from a ridge
`A`	matrix of the inner products
`lam`	coefficients of dual wavelets in reconstructed signal. They are the Lagrange multipliers λ's of the text.
`dualwave`	array containing the dual wavelets.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

skeleton2, zeroskeleton, zeroskeleton2.

---

skeleton2 *Reconstruction from Dual Wavelet*

Description

Computes the reconstructed signal from the ridge in the case of real constraints.

Usage

```
skeleton2(cwtinput, Qinv, morvelets, bridge, aridge, N)
```

Arguments

cwtinput	continuous wavelet transform (as the output of cwt).
Qinv	inverse of the reconstruction kernel (2D array).
morvelets	array of Morlet wavelets located at the ridge samples.
bridge	time coordinates of the ridge samples.
aridge	scale coordinates of the ridge samples.
N	size of reconstructed signal.

Value

Returns a list of the elements of the reconstruction of a signal from sample points of a ridge

sol	reconstruction from a ridge.
A	matrix of the inner products.
lam	coefficients of dual wavelets in reconstructed signal. They are the Lagrange multipliers λ's of the text.
dualwave	array containing the dual wavelets.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

skeleton.

smoothts *Smoothing Time Series*

Description

Smooth a time series by averaging window.

Usage

```
smoothts(ts, windowsize)
```

Arguments

`ts`	Time series.
`windowsize`	Length of smoothing window.

Value

Smoothed time series (1D array).

References

See discussions in the text of “Time-Frequency Analysis”.

smoothwt *Smoothing and Time Frequency Representation*

Description

smooth the wavelet (or Gabor) transform in the time direction.

Usage

```
smoothwt(modulus, subrate, flag=FALSE)
```

Arguments

`modulus`	Time-Frequency representation (real valued).
`subrate`	Length of smoothing window.
`flag`	If set to TRUE, subsample the representation.

Value

2D array containing the smoothed transform.

References

See discussions in the text of "Time-Frequency Analysis".

See Also

corona, coronoid, snake, snakoid.

---

snake — *Ridge Estimation by Snake Method*

Description

Estimate a ridge from a time-frequency representation, using the snake method.

Usage

```
snake(tfrep, guessA, guessB, snakesize=length(guessB),
tfspec=numeric(dim(modulus)[2]), subrate=1, temprate=3, muA=1,
muB=muA, lambdaB=2 * muB, lambdaA=2 * muA, iteration=1000000,
seed=-7, costsub=1, stagnant=20000, plot=TRUE)
```

Arguments

`tfrep`	Time-Frequency representation (real valued).
`guessA`	Initial guess for the algorithm (frequency variable).
`guessB`	Initial guess for the algorithm (time variable).
`snakesize`	the length of the initial guess of time variable.
`tfspec`	Estimate for the contribution of the noise to modulus.
`subrate`	Subsampling rate for ridge estimation.
`temprate`	Initial value of temperature parameter.
`muA`	Coefficient of the ridge's derivative in cost function (frequency component).
`muB`	Coefficient of the ridge's derivative in cost function (time component).
`lambdaB`	Coefficient of the ridge's second derivative in cost function (time component).
`lambdaA`	Coefficient of the ridge's second derivative in cost function (frequency component).
`iteration`	Maximal number of moves.
`seed`	Initialization of random number generator.
`costsub`	Subsampling of cost function in output.
`stagnant`	maximum number of steps without move (for the stopping criterion)
`plot`	when set (by default), certain results will be displayed

Value

Returns a structure containing:

`ridge`	1D array (of same length as the signal) containing the ridge.
`cost`	1D array containing the cost function.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`corona`, `coronoid`, `icm`, `snakoid`.

`snakeview` *Restriction to a Snake*

Description

Restrict time-frequency transform to a snake.

Usage

```
snakeview(modulus, snake)
```

Arguments

`modulus`	Time-Frequency representation (real valued).
`snake`	Time and frequency components of a snake.

Details

Recall that a snake is a (two components) R structure.

Value

2D array containing the restriction of the transform modulus to the snake.

References

See discussions in the text of “Time-Frequency Analysis”.

snakoid — *Modified Snake Method*

Description

Estimate a ridge from a time-frequency representation, using the modified snake method (modified cost function).

Usage

```
snakoid(modulus, guessA, guessB, snakesize=length(guessB),
tfspec=numeric(dim(modulus)[2]), subrate=1, temprate=3, muA=1,
muB=muA, lambdaB=2 * muB, lambdaA=2 * muA, iteration=1000000,
seed=-7, costsub=1, stagnant=20000, plot=TRUE)
```

Arguments

`modulus`	Time-Frequency representation (real valued).
`guessA`	Initial guess for the algorithm (frequency variable).
`guessB`	Initial guess for the algorithm (time variable).
`snakesize`	The length of the first guess of time variable.
`tfspec`	Estimate for the contribution of srthe noise to modulus.
`subrate`	Subsampling rate for ridge estimation.
`temprate`	Initial value of temperature parameter.
`muA`	Coefficient of the ridge's derivative in cost function (frequency component).
`muB`	Coefficient of the ridge's derivative in cost function (time component).
`lambdaB`	Coefficient of the ridge's second derivative in cost function (time component).
`lambdaA`	Coefficient of the ridge's second derivative in cost function (frequency component).
`iteration`	Maximal number of moves.
`seed`	Initialization of random number generator.
`costsub`	Subsampling of cost function in output.
`stagnant`	Maximum number of stationary iterations before stopping.
`plot`	when set(default), some results will be displayed

Value

Returns a structure containing:

`ridge`	1D array (of same length as the signal) containing the ridge.
`cost`	1D array containing the cost function.
`plot`	when set(default), some results will be displayed.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

corona, coronoid, icm, snake.

---

sridrec *Simple Reconstruction from Ridge*

Description

Simple reconstruction of a real valued signal from a ridge, by restriction of the transform to the ridge.

Usage

```
sridrec(tfinput, ridge)
```

Arguments

tfinput	time-frequency representation.
ridge	ridge (1D array).

Value

(real) reconstructed signal (1D array)

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

ridrec, gridrec.

SVD *Singular Value Decomposition*

Description

Computes singular value decomposition of a matrix.

Usage

```
SVD(a)
```

Arguments

a	input matrix.

Details

R interface for Numerical Recipes singular value decomposition routine.

Value

a structure containing the 3 matrices of the singular value decomposition of the input.

References

See discussions in the text of “Time-Frequency Analysis”.

Examples

```
hilbert <- function(n) { i <- 1:n; 1 / outer(i - 1, i, "+") }
  X <- hilbert(6)
  z  = SVD(X)
  z
```

tfgmax *Time-Frequency Transform Global Maxima*

Description

Computes the maxima (for each fixed value of the time variable) of the modulus of a continuous wavelet transform.

Usage

```
tfgmax(input, plot=TRUE)
```

Arguments

`input`	wavelet transform (as the output of the function `cwt`)
`plot`	if set to TRUE, displays the values of the energy as a function of the scale.

Value

`output`	values of the maxima (1D array)
`pos`	positions of the maxima (1D array)

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`tflmax`.

`tflmax` *Time-Frequency Transform Local Maxima*

Description

Computes the local maxima (for each fixed value of the time variable) of the modulus of a time-frequency transform.

Usage

```
tflmax(input, plot=TRUE)
```

Arguments

`input`	time-frequency transform (real 2D array).
`plot`	if set to T, displays the local maxima on the graphic device.

Value

values of the maxima (2D array).

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`tfgmax`.

`tfmean` *Average frequency by frequency*

Description

Compute the mean of time-frequency representation frequency by frequency.

Usage

```
tfmean(input, plot=TRUE)
```

Arguments

`input`	time-frequency transform (output of `cwt` or `cgt`).
`plot`	if set to T, displays the values of the energy as a function of the scale (or frequency).

Value

1D array containing the noise estimate.

References

See discussions in the text of "Practical Time-Frequency Analysis".

See Also

`tfpct`,`tfvar`.

`tfpct` *Percentile frequency by frequency*

Description

Compute a percentile of time-frequency representation frequency by frequency.

Usage

```
tfpct(input, percent=0.8, plot=TRUE)
```

Arguments

`input`	time-frequency transform (output of `cwt` or `cgt`).
`percent`	percentile to be retained.
`plot`	if set to T, displays the values of the energy as a function of the scale (or frequency).

Value

1D array containing the noise estimate.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

tfmean,tfvar.

---

tfvar — *Variance frequency by frequency*

Description

Compute the variance of time-frequency representation frequency by frequency.

Usage

```
tfvar(input, plot=TRUE)
```

Arguments

input	time-frequency transform (output of cwt or cgt).
plot	if set to T, displays the values of the energy as a function of the scale (or frequency).

Value

1D array containing the noise estimate.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

tfmean,tfpct.

`Undocumented` *Undocumented Functions in Rwave*

Description

Numerous functions were not documented in the original Swave help files.

References

See discussions in the text of "Practical Time-Frequency Analysis".

`vDOG` *DOG Wavelet Transform on one Voice*

Description

Compute DOG wavelet transform at one scale.

Usage

```
vDOG(input, scale, moments)
```

Arguments

`input`	Input signal (1D array).
`scale`	Scale at which the wavelet transform is to be computed.
`moments`	number of vanishing moments.

Value

1D (complex) array containing wavelet transform at one scale.

References

See discussions in the text of "Practical Time-Frequency Analysis".

See Also

`vgt`, `vwt`.

vecgabor *Gabor Functions on a Ridge*

Description

Generate Gabor functions at specified positions on a ridge.

Usage

```
vecgabor(sigsize, nbnodes, location, frequency, scale)
```

Arguments

`sigsize`	Signal size.
`nbnodes`	Number of wavelets to be generated.
`location`	b coordinates of the ridge samples (1D array of length nbnodes).
`frequency`	frequency coordinates of the ridge samples (1D array of length nbnodes).
`scale`	size parameter for the Gabor functions.

Value

size parameter for the Gabor functions.

See Also

`vecmorlet`.

vecmorlet *Morlet Wavelets on a Ridge*

Description

Generate Morlet wavelets at specified positions on a ridge.

Usage

```
vecmorlet(sigsize, nbnodes, bridge, aridge, w0=2 * pi)
```

Arguments

`sigsize`	Signal size.
`nbnodes`	Number of wavelets to be generated.
`bridge`	b coordinates of the ridge samples (1D array of length nbnodes).
`aridge`	a coordinates of the ridge samples (1D array of length nbnodes).
`w0`	Center frequency of the wavelet.

Value

2D (complex) array containing wavelets located at the specific points.

See Also

`vecgabor`.

`vgt` *Gabor Transform on one Voice*

Description

Compute Gabor transform for fixed frequency.

Usage

```
vgt(input, frequency, scale, plot=FALSE)
```

Arguments

`input`	Input signal (1D array).
`frequency`	frequency at which the Gabor transform is to be computed.
`scale`	frequency at which the Gabor transform is to be computed.
`plot`	if set to TRUE, plots the real part of cgt on the graphic device.

Value

1D (complex) array containing Gabor transform at specified frequency.

References

See discussions in the text of "Practical Time-Frequency Analysis".

See Also

`vwt`, `vDOG`.

vwt — *Voice Wavelet Transform*

Description

Compute Morlet's wavelet transform at one scale.

Usage

```
vwt(input, scale, w0=2 * pi)
```

Arguments

`input`	Input signal (1D array).
`scale`	Scale at which the wavelet transform is to be computed.
`w0`	Center frequency of the wavelet.

Value

1D (complex) array containing wavelet transform at one scale.

References

See discussions in the text of "Practical Time-Frequency Analysis".

See Also

`vgt`, `vDOG`.

wpl — *Plot Dyadic Wavelet Transform.*

Description

Plot dyadic wavelet transform(output of `mw`).

Usage

```
wpl(dwtrans)
```

Arguments

`dwtrans`	dyadic wavelet transform (output of `mw`).

See Also

`mw`, `ext`,`epl`.

wRidgeSampling — *Sampling wavelet Ridge*

Description

Given a ridge ϕ (for the wavelet transform), returns a (appropriately) subsampled version with a given subsampling rate.

Usage

```
wRidgeSampling(phi, compr, nvoice)
```

Arguments

`phi`	ridge (1D array).
`compr`	subsampling rate for the ridge.
`nvoice`	number of voices per octave.

Details

To account for the variable sizes of wavelets, the sampling rate of a wavelet ridge is not uniform, and is proportional to the scale.

Value

Returns a list containing the discrete values of the ridge.

`node`	time coordinates of the ridge samples.
`phinode`	scale coordinates of the ridge samples.
`nbnode`	number of nodes of the ridge samples.

See Also

`RidgeSampling`.

wspec.pl — *Log of Wavelet Spectrum Plot*

Description

Displays normalized log of wavelet spectrum.

Usage

```
wspec.pl(wspec, nvoice)
```

Arguments

`wspec`	wavelet spectrum.
`nvoice`	number of voices.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

See Also

`hurst.est`.

WV — *Wigner-Ville function*

Description

Compute the Wigner-Ville transform, without any smoothing.

Usage

```
WV(input, nvoice, freqstep = (1/nvoice), plot = TRUE)
```

Arguments

`input`	input signal (possibly complex-valued)
`nvoice`	number of frequency bands
`freqstep`	sampling rate for the frequency axis
`plot`	if set to TRUE, displays the modulus of CWT on the graphic device.

Value

(complex) Wigner-Ville transform.

References

See discussions in the text of “Practical Time-Frequency Analysis”.

`W_tilda.1` *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(W_tilda.1)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942), eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(W_tilda.1)
plot.ts(W_tilda.1)
```

W_tilda.2 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(W_tilda.2)
```

Format

A vector containing observations.

Source

See discussions in the text of "Practical Time-Frequency Analysis".

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942), eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(W_tilda.2)
plot.ts(W_tilda.2)
```

W_tilda.3 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(W_tilda.3)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942), eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(W_tilda.3)
plot.ts(W_tilda.3)
```

W_tilda.4 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(W_tilda.4)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942), eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(W_tilda.4)
plot.ts(W_tilda.4)
```

W_tilda.5 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(W_tilda.5)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942), eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(W_tilda.5)
plot.ts(W_tilda.5)
```

W_tilda.6 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(W_tilda.6)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942), eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(W_tilda.6)
plot.ts(W_tilda.6)
```

W_tilda.7 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(W_tilda.7)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942), eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(W_tilda.7)
plot.ts(W_tilda.7)
```

W_tilda.8 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(W_tilda.8)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942), eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(W_tilda.8)
plot.ts(W_tilda.8)
```

W_tilda.9 *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(W_tilda.9)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942), eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(W_tilda.9)
plot.ts(W_tilda.9)
```

`yen` *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(yen)
```

Format

A vector containing observations.

Source

See discussions in the text of “Practical Time-Frequency Analysis”.

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(yen)
plot.ts(yen)
```

yendiff *Pixel from Amber Camara*

Description

Pixel from amber camara.

Usage

```
data(yendiff)
```

Format

A vector containing observations.

Source

See discussions in the text of "Practical Time-Frequency Analysis".

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(yendiff)
plot.ts(yendiff)
```

YN *Logarithms of the Prices of Japanese Yen*

Description

Logarithms of the prices of a contract of Japanese yen.

Usage

```
data(YN)
```

Format

A vector containing 500 observations.

Source

See discussions in the text of "Practical Time-Frequency Analysis".

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(YN)
plot.ts(YN)
```

YNdiff *Daily differences of Japanese Yen*

Description

Daily differences of YN.

Usage

```
data(YNdiff)
```

Format

A vector containing 499 observations.

Source

See discussions in the text of "Practical Time-Frequency Analysis".

References

Carmona, R. A., W. L. Hwang and B Torresani (1998, eBook ISBN:978008053942) *Practical Time-Frequency Analysis: Gabor and Wavelet Transforms with an Implementation in S*, Academic Press, San Diego.

Examples

```
data(YNdiff)
plot.ts(YNdiff)
```

zerokernel *Reconstruction from Wavelet Ridges*

Description

Generate a zero kernel for reconstruction from ridges.

Usage

```
zerokernel(x.inc=1, x.min, x.max)
```

Arguments

x.min	minimal value of x for the computation of Q_2.
x.max	maximal value of x for the computation of Q_2.
x.inc	step unit for the computation of the kernel.

Value

matrix of the Q_2 kernel

See Also

kernel, fastkernel, gkernel, gkernel.

zeroskeleton *Reconstruction from Dual Wavelets*

Description

Computes the the reconstructed signal from the ridge when the epsilon parameter is set to zero

Usage

```
zeroskeleton(cwtinput, Qinv, morvelets, bridge, aridge, N)
```

Arguments

cwtinput	continuous wavelet transform (as the output of cwt).
Qinv	inverse of the reconstruction kernel (2D array).
morvelets	array of Morlet wavelets located at the ridge samples.
bridge	time coordinates of the ridge samples.
aridge	scale coordinates of the ridge samples.
N	size of reconstructed signal.

Details

The details of this reconstruction are the same as for the function skeleton. They can be found in the text

Value

Returns a list of the elements of the reconstruction of a signal from sample points of a ridge

sol	reconstruction from a ridge.
A	matrix of the inner products.
lam	coefficients of dual wavelets in reconstructed signal. They are the Lagrange multipliers λ's of the text.
dualwave	array containing the dual wavelets.

References

See discussions in the text of "Practical Time-Frequency Analysis".

See Also

skeleton, skeleton2, zeroskeleton2.

---

zeroskeleton2 *Reconstruction from Dual Wavelets*

Description

Computes the the reconstructed signal from the ridge when the epsilon parameter is set to zero, in the case of real constraints.

Usage

```
zeroskeleton2(cwtinput, Qinv, morvelets, bridge, aridge, N)
```

Arguments

cwtinput	continuous wavelet transform (output of cwt).
Qinv	inverse of the reconstruction kernel (2D array).
morvelets	array of Morlet wavelets located at the ridge samples.
bridge	time coordinates of the ridge samples.
aridge	scale coordinates of the ridge samples.
N	size of reconstructed signal.

Details

The details of this reconstruction are the same as for the function skeleton. They can be found in the text

Value

Returns a list of the elements of the reconstruction of a signal from sample points of a ridge

`sol`	reconstruction from a ridge.
`A`	matrix of the inner products.
`lam`	coefficients of dual wavelets in reconstructed signal. They are the Lagrange multipliers λ's of the text.
`dualwave`	array containing the dual wavelets.

References

See discussions in the text of "Practical Time-Frequency Analysis".

See Also

`skeleton`, `skeleton2`, `zeroskeleton`.

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