Package ‘LSWPlib’

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Type Package

Title Simulation and Spectral Estimation of Locally Stationary Wavelet Packet Processes

Version 0.1.0

Description Library of functions for the statistical analysis and simulation of Locally Stationary Wavelet Packet (LSWP) processes. The methods implemented by this library are described in Cardinali and Nason (2017) <doi:10.1111/jtsa.12230>.

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R topics documented:

autoconv .................................................. 2
best.basis .................................................. 3
get.flat.basis ............................................. 4
get.wavelet.basis ........................................ 5
LSWPbasis ................................................ 6
LSWPlib .................................................. 7
LSWPsim .................................................. 7
LSWPspec ................................................ 8
marg.spec ............................................... 10
autoconv

Description
autoconv computes the linear convolution of a numeric vector with itself. It is based on the \texttt{fft} function and is twicked to achieve maximum performance.

Usage
\texttt{autoconv(x)}

Arguments
\begin{itemize}
  \item \texttt{x} \hspace{1cm} a real or complex vector
\end{itemize}

Details
The speed of calculation for the linear convolution depends upon the number of factors in the number representing the vector length. This implementation maximizes calculation speed for vectors of dyadic length, or lengths with a single factor.

Value
The linear auto convolution of a given vector with itself, which is equivalent with its inner product.

Author(s)
Alessandro Cardinali

References

See Also
\texttt{fft, convolve}.

Examples
\begin{verbatim}
v <- rnorm(n = 64)
vv <- autoconv(x = v)
\end{verbatim}
**Description**

`best.basis` returns a selection of packets from a dyadic tree where the selection is made by minimizing the cost functionals associated with each packet.

**Usage**

```r
best.basis(wpc)
```

**Arguments**

- `wpc` this is a list containing the cost functionals associated with each packet. Each element in the list corresponds to a level of the dyadic tree.

**Details**

The function implements best basis selection from an arbitrary tree. Typically this tree is produced by other functions in this package and this function is also used to produce a selected basis. Since best basis methods are of general interest this function has been exported for possible other uses.

**Value**

A matrix of two columns where each row refers to a different selected packet. The first index refers to the tree level, the second index refers to the packet within that level.

**Author(s)**

Alessandro Cardinali

**References**


**See Also**

`LSWPbasis`, `LSWPspec`.

**Examples**

```r
costs <- vector(mode = 'list', length = 4)
for(i in 1:4) costs[[i]] <- rnorm(2^i)^2
best.basis(wpc = costs)
```
get.flat.basis

Wavelet Packet Basis for a single scale

**Description**

get.flat.basis returns the full set of packet indices relative to a basis for a single scale from the wavelet packet table.

**Usage**

get.flat.basis(scale)

**Arguments**

scale  
The scale for which the indices of wavelet packet basis are returned. Typically this is a positive integer.

**Details**

This function is used internally by other routines but it might be useful when the wavelet packet spectral estimation over a fixed scale is of interest. The function returns an object of class lswpbb, whose structure is the same to the object produced by best.basis.

**Value**

A matrix of two columns where each row refers to a different selected packet. The first index is the argument scale, the second index refers to the packet within this level.

**Author(s)**

Alessandro Cardinali

**References**


**See Also**

best.basis, get.wavelet.basis

**Examples**

get.flat.basis(scale = 4)
**get.wavelet.basis**

**Wavelet Packet indices for a Wavelet Basis**

**Description**

`get.wavelet.basis` returns the full set of packet indices relative to a wavelet basis selected from the wavelet packet table.

**Usage**

`get.wavelet.basis(scale)`

**Arguments**

- `scale` The maximum scale for which the indices of the wavelet basis are returned. Typically this is a positive integer.

**Details**

This function is used internally by other routines but it might be useful when the ‘classical’ wavelet spectral estimation is of interest. The function returns an object of class `LSWPbasis`, whose structure is the same to the object produced by `best.basis`.

**Value**

A matrix of two columns where each row refers to a different selected packet. The first index refers to each given scale, the second index refers to the packet within this level.

**Author(s)**

Alessandro Cardinali

**References**


**See Also**

`best.basis, get.flat.basis`

**Examples**

`get.wavelet.basis(scale = 4)`
**LSWPbasis**

Estimate an LSWP basis by penalised least squares

**Description**

`LSWPbasis` returns a matrix containing the wavelet packet basis indices.

**Usage**

```r
LSWPbasis(x, wavelet, lev.max, smooth, spa, penalty = 0.976)
```

**Arguments**

- `x`: a (locally stationary) time series of dyadic length.
- `wavelet`: the wavelet used to estimate the wavelet packet spectra.
- `lev.max`: the maximum scale for which the basis is fitted.
- `smooth`: should the penalised least squares cost functionals be smoothed? Default value is `TRUE`.
- `spa`: parameter for the local polynomial smoothing implemented through `lowess`
- `penalty`: implements increasing penalty for increasing scales.

**Details**

This function fits a wavelet packet basis to data using a penalised least square method.

This function implements a data-driven basis selection of locally stationary time series. The wavelet argument is specified as in other functions of this package. Therefore, the current implementation allows for three discrete wavelets: Haar ("haar"), Daubechies Extremal Phase linear filters of length 4 ("d4") and Least Asymmetric linear filters of length 8 ("la8"). Smoothing is controlled through the argument `spa`.

**Value**

A matrix of dimensions |b| x 2, where |b| is the number of packets in the basis. The first column contains the scale indices of each packet in the basis, the second column contains the packet index within each scale.

**Author(s)**

Alessandro Cardinali

**References**

See Also

LSWPspec, LSWPsim

Examples

wpb <- LSWPbasis(x = sp500, wavelet = 'la8', lev.max = 4, smooth = TRUE, spa = 0.35)

LSWPlib

Library of functions for the statistical analysis and simulation of LSWP processes.

Author(s)

Alessandro Cardinali <alessandro.cardinali@plymouth.ac.uk>

LSWPsim

Simulation of LSWP processes

Description

LSWPsim returns simulated time series from a specified LSWP specification.

Usage

LSWPsim(bb, spec, lev, wavelet, N)

Arguments

bb a wavelet packet basis for the simulated process.

spec a (locally stationary) spectra corresponding to the wavelet packet basis.

lev the maximum level of the basis that is considered for simulation. Usually this is set as the maximum level in bb.

wavelet the Daubechies wavelet used to build wavelet packets to simulate the process. See also Details.

N the number of realizations to be simulated.
Details

This function produces one or multiple realizations of an LSWP process that is specified in terms of a wavelet packet basis and its corresponding spectra.

The function simulates realizations accordingly to the specified arguments. The wavelet argument is specified as in other functions of this package. Therefore, the current implementation allows for three discrete wavelets: Haar ("haar"), Daubechies Extremal Phase linear filters of length 4 ("d4") and Least Asymmetric linear filters of length 8 ("la8").

Value

If \( N = 1 \) the function returns a vector containing the simulated time series. If \( N > 1 \) the function returns a matrix with \( N \) columns each containing a different simulated series.

Author(s)

Alessandro Cardinali

References


See Also

LSWPspec, best.basis, get.flat.basis, get.wavelet.basis.

Examples

```r
wwb <- get.flat.basis(scale = 4)
wwp <- matrix(2^(-(1:4)), nrow = 4, ncol = 512, byrow = FALSE)
xt <- LSWPsim(bb = wwb, spec = wwp, lev = 4, wavelet = "la8", N = 10)
```
Arguments

- **x**: a real valued numeric vector containing a time series of dyadic length.
- **lev**: the maximum level for which the spectra should be estimated.
- **bb**: a wavelet packet basis for which the spectra is estimated.
- **wavelet**: wavelet used to estimate the wavelet packet spectra. Possible values are "haar", "d4" and "la8". See also Details.
- **smooth**: logical. If FALSE the returned spectral estimate is not smoothed. Default value is FALSE. See also Details.
- **spa**: window length for spectral smoothing. Increasing values increase the smoothing.
- **correct**: logical. Should the returned spectral estimate be unbiased? Default is TRUE.
- **AA**: this argument is for internal use only and should be left alone. See also Details.

Details

The current implementation allow the use of these three well known Daubechies discrete wavelets for spectral estimation. Default choice is the "la8" wavelet which has decent control over frequency leakage characterizing compactly supported filters. In this initial implementation smoothing is provided by local polynomials through the lowess function and the smoothing parameter spa is passed to lowess. Future package versions will allow for different smoothing methods. The argument AA is tipically used by other functions to provide the inner product matrix when running simulations. For a direct usage on a single time series the matrix is calculated internally usig the default settings.

Value

A matrix containing the time-frequency spectral estimate where each column corresponds to a different time point and ech row corresponds to a different packet from the given basis.

Author(s)

Alessandro Cardinali

References


See Also

gt.wavelet.basis, LSWPsim, best.basis.

Examples

```r
wb = get.wavelet.basis(4)
wp = LSWPspec(x = sp500, lev = 4, bb = wb, wavelet = 'la8', smooth = TRUE, spa = 0.35)
```
marg.spec

Wavelet Packet Marginal Spectra

Description

marg.spec returns the time-average spectra of LSWP processes for each packet.

Usage

marg.spec(bas, spec, plot = TRUE)

Arguments

bas is a (|b| x 2) matrix containing indices of a wavelet packet basis, where |b| is the number of packets in the basis.

spec is a (|b| x T) matrix containing, in each row, the values of the time-varying spectra for each packet.

plot should a plot of the marginal spectra vs frequency intervals be returned?

Details

This function computes the frequency intervals corresponding to each packet, along with the (time) average spectra for each packet.

This function is used to compute, and eventually plot, the time averaged spectra (or spectral estimate) vs packet frequencies. The arguments bas and spec should be provided as matrices.

Value

A (|b| x 2) matrix. In the first column the lower frequency relative to each packet is displayed. The second column contains the (time) average spectra.

Author(s)

Alessandro Cardinali

References


See Also

best.basis, get.wavelet.basis
Examples

wwb <- get.wavelet.basis(scale = 4)
wwp <- matrix(2^{-(1:4)}, nrow = 4, ncol = 512, byrow = FALSE)
msp <- marg.spec(bas = wwb, spec = wwp, plot = TRUE)

Description

plot.LSWPspec returns the plot for objects of class "LSWPspec", typically (but not exclusively) a wavelet packet spectral estimate.

Usage

## S3 method for class 'LSWPspec'
plot(x, y, ...)

Arguments

x an object of class lswpspec.
y not used, is set to NULL.
... not currently used.

Details

This function implements the plot method for objects of class "LSWPspec". It is mainly used to plot spectral estimates returned by LSWPspec. The label of the vertical axis uses the wavelet packet basis index notation \( p = 1, 2, \ldots, |b| \), where \(|b|\) is the number of packets in a wavelet packet basis as defined in Cardinali and Nason (2017). The label of the horizontal axis is the time index.

Value

A plot of the time-varying spectral estimates.

Author(s)

Alessandro Cardinali

References

See Also

LSWPspec, LSWPbasis

Examples

```r
wb <- get.wavelet.basis(4)
wpp <- LSWPspec(x = sp500, lev = 4, bb = wb, wavelet = 'la8', smooth = TRUE, spa = 0.35)
plot(wpp)
```

sp500

*Daily log-returns for the S&P 500 stock index.*

Description

Log-returns from daily quotes of the Standard & Poors 500 Index.

Usage

sp500

Format

A vector containing 1024 daily log-returns.

**Period Covered**

The data cover the period April 1996 - December 1999.

summary.LSWPbasis

*Summary method for Objects of Class LSWPbasis*

Description

summary.LSWPbasis returns a table containing the wavelet packet basis and its wavelet packet bases index notation.

Usage

```r
## S3 method for class 'LSWPbasis'
summary(object, ...)
```

Arguments

- `object` an object of class "LSWPbasis", typically (but not exclusively) returned by the function LSWPbasis.
- `...` not currently used.
summary.LSWPbasis

Details

This function is used to print a wavelet packet basis with the wavelet packet basis index notation \( p = 1, 2, \ldots, |b| \), where \(|b|\) is the number of packets in a wavelet packet basis as defined in Cardinali and Nason (2017). The doublets "\( j_p, i_p \)" refer to the scale and packet index within each scale, respectively.

Value

Print an object of class LSWPbasis with LSWP basis notation.

Author(s)

Alessandro Cardinali

References


See Also

LSWPbasis, best.basis

Examples

wpb <- LSWPbasis(x = sp500, wavelet = 'la8', lev.max = 4, smooth = TRUE, spa = 0.35)
summary(wpb)
Index

* datasets
  - sp500, 12
autoconv, 2
best.basis, 3, 4, 5, 8–10, 13
convolve, 2
fft, 2
get.flat.basis, 4, 5, 8
get.wavelet.basis, 4, 5, 8–10
LSWPbasis, 3, 6, 12, 13
LSWPlib, 7
LSWPsim, 7, 7, 9
LSWPspec, 3, 7, 8, 8, 12
marg.spec, 10
plot.LSWPspec, 11
sp500, 12
summary.LSWPbasis, 12