Package ‘vectorwavelet’

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Type Package

Title Vector Wavelet Coherence for Multiple Time Series

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to handle dynamic co-movements of multivariate time series via extending multiple and quadruple wavelet coherence methodologies.
This package can be used to perform multiple wavelet coherence, quadruple wavelet coherence, and n-dimensional vector wavelet coherence analyses.

License GPL (>= 2)

URL https://github.com/toygur/vectorwavelet

BugReports https://github.com/toygur/vectorwavelet/issues

Depends biwavelet (>= 0.20.19)

Imports iterators, spam, maps, fields, foreach, Rcpp

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**Description**

Description: This package can be used to perform multiple wavelet coherence (mwc), quadruple wavelet coherence (qmwc), and n-dimensional vector wavelet coherence (vwc) analyses.

**Author(s)**

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Code based on biwavelet package written by Tarik C. Gouhier, Aslak Grinsted, Viliam Simko.

**References**


T. Oygur, G. Unal.. The large fluctuations of the stock return and financial crises evidence from Turkey: using wavelet coherency and VARMA modeling to forecast stock return. _Fluctuation and Noise Letters_, 2017

T.C. Gouhier, A. Grinstead and V. Simko. 2016. _biwavelet: Conduct univariate and bivariate wavelet analyses (Version 0.20.15)._ Available from http://github.com/tgouhier/biwavelet

Ng, Eric KW and Chan, Johnny CL. 2012. Geophysical applications of partial wavelet coherence and multiple wavelet coherence. _Journal of Atmospheric and Oceanic Technology_ 29-12:1845–1853.


**AR1NV - Estimate the parameters for an AR(1) model**

**Description**

AR1NV - Estimate the parameters for an AR(1) model

**Usage**

\[ ar1nv(x) \]

**Arguments**

- **x**: One dimensional time series vector

**Value**

Return a list containing:

- **g**: estimate of the lag-one autocorrelation.
- **a**: estimate of the noise variance.

**Author(s)**

Tunc Oygur (info@tuncoygur.com.tr)

Code based on a cross wavelet and wavelet coherence toolbox MATLAB package written by Eric Breitenberger

**References**


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**mwc**

*Compute multiple wavelet coherence*

**Description**

Compute multiple wavelet coherence
Usage

\texttt{mwc(}
\begin{itemize}
\item \texttt{y,} \\
\item \texttt{x1,} \\
\item \texttt{x2,} \\
\item \texttt{pad = TRUE,} \\
\item \texttt{dj = 1/12,} \\
\item \texttt{s0 = 2 * dt,} \\
\item \texttt{J1 = NULL,} \\
\item \texttt{max.scale = NULL,} \\
\item \texttt{mother = "morlet",} \\
\item \texttt{param = -1,} \\
\item \texttt{lag1 = NULL,} \\
\item \texttt{sig.level = 0.95,} \\
\item \texttt{sig.test = 0,} \\
\item \texttt{nrands = 300,} \\
\item \texttt{quiet = FALSE}
\end{itemize}
\texttt{)}

Arguments

\texttt{y} time series 1 in matrix format (\(m\) rows x 2 columns). The first column should contain the time steps and the second column should contain the values.

\texttt{x1} time series 2 in matrix format (\(m\) rows x 2 columns). The first column should contain the time steps and the second column should contain the values.

\texttt{x2} time series 3 in matrix format (\(m\) rows x 2 columns). The first column should contain the time steps and the second column should contain the values.

\texttt{pad} pad the values will with zeros to increase the speed of the transform. Default is TRUE.

\texttt{dj} spacing between successive scales. Default is 1/12.

\texttt{s0} smallest scale of the wavelet. Default is 2*dt.

\texttt{J1} number of scales - 1.

\texttt{max.scale} maximum scale. Computed automatically if left unspecified.

\texttt{mother} type of mother wavelet function to use. Can be set to morlet, dog, or paul. Default is morlet. Significance testing is only available for morlet wavelet.

\texttt{param} nondimensional parameter specific to the wavelet function.

\texttt{lag1} vector containing the AR(1) coefficient of each time series.

\texttt{sig.level} significance level. Default is 0.95.

\texttt{sig.test} type of significance test. If set to 0, use a regular \(\chi^2\) test. If set to 1, then perform a time-average test. If set to 2, then do a scale-average test.

\texttt{nrands} number of Monte Carlo randomizations. Default is 300.

\texttt{quiet} Do not display progress bar. Default is FALSE.
Value

Return a vectorwavelet object containing:

- coi: matrix containing cone of influence
- rsq: matrix of wavelet coherence
- phase: matrix of phases
- period: vector of periods
- scale: vector of scales
- dt: length of a time step
- t: vector of times
- xaxis: vector of values used to plot xaxis
- s0: smallest scale of the wavelet
- dj: spacing between successive scales
- mother: mother wavelet used
- type: type of vectorwavelet object created (mwc)
- signif: matrix containing sig.level percentiles of wavelet coherence based on the Monte Carlo AR(1) time series

Author(s)

Tunc Oygur (info@tuncoygur.com.tr)

Code based on MWC MATLAB package written by Eric K. W. Ng and Johnny C. L. Chan.

References


Ng, Eric KW and Chan, Johnny CL. 2012. Geophysical applications of partial wavelet coherence and multiple wavelet coherence. *Journal of Atmospheric and Oceanic Technology* 29-12:1845–1853.

Examples

```r
old.par <- par(no.readonly=TRUE)

t <- (-100:100)

y <- sin(t*2*pi)+sin(t*2*pi/4)+sin(t*2*pi/8)+sin(t*2*pi/16)+sin(t*2*pi/32)+sin(t*2*pi/64)
x1 <- sin(t*2*pi/8)
x2 <- sin(t*2*pi/32)
y <- cbind(t,y)
```
n.check.data

Check the format of multivariate time series

Description

Check the format of multivariate time series

Usage

n.check.data(y, x = NULL)

Arguments

y  
  time series y in matrix format (m rows x 2 columns). The first column should contain the time steps and the second column should contain the values.

x  
  multivariate time series x in matrix format (m rows x (1 + (n-1)) columns). The first column should contain the time steps and the other columns should contain the values.

Value

Returns a named list containing:

t  time steps

dt  size of a time step

n.obs  number of observations

Author(s)

Tunc Oygur (info@tuncoygur.com.tr)

Code based on biwavelet package written by Tarik C. Gouhier.
Examples

#Example 1:
```r
t1 <- cbind(1:100, rnorm(100))
n.check.data(y = t1)
```

#Example 2:
```r
t1 <- cbind(1:100, rnorm(100))
t2 <- cbind(1:100, rnorm(100), rnorm(100), rnorm(100))
n.check.data(y = t1, x = t2)
```

## n.check.datum

### Helper function

#### Description
Helper function

#### Usage
```r
n.check.datum(x)
```

#### Arguments
- `x`: matrix

#### Value
list(t, dt, n.obs)

#### Note
This function is not exported

## plot.vectorwavelet

### Plot vectorwavelet objects

#### Description
Plot vectorwavelet objects which are multiple wavelet coherence, quadruple wavelet coherence and n-dimensional vector wavelet coherence.
Usage

## S3 method for class 'vectorwavelet'
plot(
  x,
  ncol = 1024,
  fill.cols = NULL,
  xlab = "Time",
  ylab = "Period",
  tol = 1,
  plot.cb = FALSE,
  plot.coi = TRUE,
  lwd.coi = 1,
  col.coi = "white",
  lty.coi = 1,
  alpha.coi = 0.5,
  plot.sig = TRUE,
  lwd.sig = 4,
  col.sig = "black",
  lty.sig = 1,
  bw = FALSE,
  legend.loc = NULL,
  legend.horiz = FALSE,
  arrow.len = min(par()$pin[2]/30, par()$pin[1]/40),
  arrow.lwd = arrow.len * 0.3,
  arrow.cutoff = 0.7,
  arrow.col = "black",
  xlim = NULL,
  ylim = NULL,
  zlim = c(0, 1),
  xaxt = "s",
  yaxt = "s",
  form = "%Y",
  ...
)

Arguments

x vectorwavelet object generated by mwc, qmec, or vwc.
ncol number of colors to use. Default is 1024.
fill.cols Vector of fill colors to be used. Users can specify color vectors using colorRampPalette or brewer.pal from package RColorBrewer. Default is NULL and will generate MATLAB's jet color palette.
xlab xlabel of the figure. Default is "Time"
ylab ylabel of the figure. Default is "Period"
tol tolerance level for significance contours. Significance contours will be drawn around all regions of the spectrum where \( \frac{spectrum}{percentile} \geq tol \). De-
fault is 1. If strict $i^\text{th}$ percentile regions are desired, then tol must be set to 1.

- **plot.cb**: plot color bar if TRUE. Default is FALSE.
- **plot.coi**: plot cone of influence (COI) as a semi-transparent polygon if TRUE. Default is TRUE. Areas that fall within the polygon can be affected by edge effects.
- **lwd.coi**: Line width of COI. Default is 1.
- **col.coi**: Color of COI. Default is white.
- **lty.coi**: Line type of COI. Default is 1 for solid lines.
- **alpha.coi**: Transparency of COI. Range is 0 (full transparency) to 1 (no transparency). Default is 0.5.
- **plot.sig**: plot contours for significance if TRUE. Default is TRUE.
- **lwd.sig**: Line width of significance contours. Default is 4.
- **col.sig**: Color of significance contours. Default is black.
- **lty.sig**: Line type of significance contours. Default is 1.
- **bw**: plot in black and white if TRUE. Default is FALSE.
- **legend.loc**: legend location coordinates as defined by image.plot. Default is NULL.
- **legend.horiz**: plot a horizontal legend if TRUE. Default is FALSE.
- **arrow.len**: size of the arrows. Default is based on plotting region (min(par())$pin[2]/30,par()$pin[1]/40).
- **arrow.lwd**: width/thickness of arrows. Default is arrow.len*0.3.
- **arrow.cutoff**: cutoff value for plotting phase arrows. Phase arrows will be plotted in regions where the significance of the zvalues exceeds arrow.cutoff. If the object being plotted does not have a significance field, regions whose zvalues exceed the arrow.cutoff quantile will be plotted. Default is 0.7.
- **arrow.col**: Color of arrows. Default is black.
- **xlim**: the x limits. The default is NULL.
- **ylim**: the y limits. The default is NULL.
- **zlim**: the z limits. The default is NULL.
- **xaxt**: Add x-axis? The default is s; use n for none.
- **yaxt**: Add y-axis? The default is s; use n for none.
- **form**: format to use to display dates on the x-axis. Default is '%Y' for 4-digit year. See ?Date for other valid formats.
- **...**: other parameters.

**Value**

No return value, shows the objects plot.

**Author(s)**

Tunc Oygur (info@tuncoygur.com.tr)

Code based on biwavelet package written by Tarik C. Gouhier.
Compute quadruple wavelet coherence

Description

Compute quadruple wavelet coherence

Usage

```r
qmwc(
  y,
  x1,
  x2,
  x3,
  pad = TRUE,
  dj = 1/12,
  s0 = 2 * dt,
  J1 = NULL,
  max.scale = NULL,
  mother = "morlet",
  param = -1,
  lagl = NULL,
  sig.level = 0.95,
  sig.test = 0,
  nrands = 300,
  quiet = FALSE
)
```

Arguments

- **y**: time series 1 in matrix format (n rows x 2 columns). The first column should contain the time steps and the second column should contain the values.
- **x1**: time series 2 in matrix format (n rows x 2 columns). The first column should contain the time steps and the second column should contain the values.
- **x2**: time series 3 in matrix format (n rows x 2 columns). The first column should contain the time steps and the second column should contain the values.
- **x3**: time series 4 in matrix format (n rows x 2 columns). The first column should contain the time steps and the second column should contain the values.
- **pad**: pad the values will with zeros to increase the speed of the transform. Default is TRUE.
- **dj**: spacing between successive scales. Default is 1/12.
- **s0**: smallest scale of the wavelet. Default is 2*dt.
- **J1**: number of scales - 1.
- **max.scale**: maximum scale. Computed automatically if left unspecified.
mother type of mother wavelet function to use. Can be set to morlet, dog, or paul. Default is morlet. Significance testing is only available for morlet wavelet.

param nondimensional parameter specific to the wavelet function.

lag1 vector containing the AR(1) coefficient of each time series.

sig.level significance level. Default is 0.95.

sig.test type of significance test. If set to 0, use a regular $\chi^2$ test. If set to 1, then perform a time-average test. If set to 2, then do a scale-average test.

nrands number of Monte Carlo randomizations. Default is 300.

quiet Do not display progress bar. Default is FALSE

Value

Return a vectorwavelet object containing:

coi matrix containing cone of influence

rsq matrix of wavelet coherence

phase matrix of phases

period vector of periods

scale vector of scales

dt length of a time step

t vector of times

xaxis vector of values used to plot xaxis

s0 smallest scale of the wavelet

dj spacing between successive scales

mother mother wavelet used

type type of vectorwavelet object created (qmwc)

signif matrix containing sig.level percentiles of wavelet coherence based on the Monte Carlo AR(1) time series

Author(s)

Tunc Oygur (info@tuncoygur.com.tr)

References


Examples

```r
old.par <- par(no.readonly=TRUE)

t <- (-100:100)

y <- sin(t*2*pi)+sin(t*2*pi/4)+sin(t*2*pi/8)+sin(t*2*pi/16)+sin(t*2*pi/32)+sin(t*2*pi/64)
x1 <- sin(t*2*pi/16)
x2 <- sin(t*2*pi/32)
x3 <- sin(t*2*pi/64)

y <- cbind(t,y)
x1 <- cbind(t,x1)
x2 <- cbind(t,x2)
x3 <- cbind(t,x3)

## Quadruple wavelet coherence
result <- qmwc(y, x1, x2, x3, nrands = 10)

result <- qmwc(y, x1, x2, x3)

## Plot wavelet coherence and make room to the right for the color bar
## Note: plot function can be used instead of plot.vectorwavelet
par(oma = c(0, 0, 0, 1), mar = c(5, 4, 4, 5) + 0.1, pin = c(3,3))
plot.vectorwavelet(result, plot.cb = TRUE, main = "Plot quadruple wavelet coherence")
par(old.par)
```

---

### vwc

**Compute n-dimensional vector wavelet coherence**

#### Description

Compute n-dimensional vector wavelet coherence

#### Usage

```r
vwc(
    y, x,
    pad = TRUE,
    dj = 1/12,
    s0 = 2 * dt,
    J1 = NULL,
    max.scale = NULL,
    mother = "morlet",
    param = -1,
    lag1 = NULL,
)```
\[ \text{sig.level} = 0.95, \]
\[ \text{sig.test} = 0, \]
\[ \text{nrands} = 300, \]
\[ \text{quiet} = \text{FALSE} \]

\textbf{Arguments}

\textbf{y} \hspace{1cm} \text{time series y in matrix format (m rows x 2 columns). The first column should contain the time steps and the second column should contain the values.}

\textbf{x} \hspace{1cm} \text{multivariate time series x in matrix format (m rows x n columns). The first column should contain the time steps and the other columns should contain the values.}

\textbf{pad} \hspace{1cm} \text{pad the values will with zeros to increase the speed of the transform. Default is TRUE.}

\textbf{dj} \hspace{1cm} \text{spacing between successive scales. Default is 1/12.}

\textbf{s0} \hspace{1cm} \text{smallest scale of the wavelet. Default is } 2 \times \text{dt}.\]

\textbf{J1} \hspace{1cm} \text{number of scales - 1.}

\textbf{max.scale} \hspace{1cm} \text{maximum scale. Computed automatically if left unspecified.}

\textbf{mother} \hspace{1cm} \text{type of mother wavelet function to use. Can be set to } \text{morlet}, \text{dog, or paul}. \text{Default is } \text{morlet}. \text{Significance testing is only available for } \text{morlet} \text{ wavelet.}

\textbf{param} \hspace{1cm} \text{nondimensional parameter specific to the wavelet function.}

\textbf{lag1} \hspace{1cm} \text{vector containing the AR(1) coefficient of each time series.}

\textbf{sig.level} \hspace{1cm} \text{significance level. Default is 0.95.}

\textbf{sig.test} \hspace{1cm} \text{type of significance test. If set to 0, use a regular } \chi^2 \text{ test. If set to 1, then perform a time-average test. If set to 2, then do a scale-average test.}

\textbf{nrands} \hspace{1cm} \text{number of Monte Carlo randomizations. Default is 300.}

\textbf{quiet} \hspace{1cm} \text{Do not display progress bar. Default is FALSE}

\textbf{Value}

\text{Return a vectorwavelet object containing:}

\textbf{coi} \hspace{1cm} \text{matrix containing cone of influence}

\textbf{rsq} \hspace{1cm} \text{matrix of wavelet coherence}

\textbf{phase} \hspace{1cm} \text{matrix of phases}

\textbf{period} \hspace{1cm} \text{vector of periods}

\textbf{scale} \hspace{1cm} \text{vector of scales}

\textbf{dt} \hspace{1cm} \text{length of a time step}

\textbf{t} \hspace{1cm} \text{vector of times}

\textbf{xaxis} \hspace{1cm} \text{vector of values used to plot xaxis}

\textbf{s0} \hspace{1cm} \text{smallest scale of the wavelet}
dj spacing between successive scales

mother mother wavelet used

type type of vectorwavelet object created (vwc)

signif matrix containing sig.level percentiles of wavelet coherence based on the Monte Carlo AR(1) time series

Author(s)

Tunc Oygur (info@tuncoygur.com.tr)

References


Examples

old.par <- par(no.readonly=TRUE)

t <- (-100:100)

y <- sin(t*2*pi)+sin(t*2*pi/4)+sin(t*2*pi/8)+sin(t*2*pi/16)+sin(t*2*pi/32)+sin(t*2*pi/64)
x1 <- sin(t*2*pi/8)
x2 <- sin(t*2*pi/16)
x3 <- sin(t*2*pi/32)
x4 <- sin(t*2*pi/64)

y <- cbind(t,y)
x <- cbind(t,x1,x2,x3,x4)

## n-dimensional multiple wavelet coherence
result <- vwc(y, x, nrands = 10)

result <- vwc(y, x)

## Plot wavelet coherence and make room to the right for the color bar
## Note: plot function can be used instead of plot.vectorwavelet
par(oma = c(0, 0, 0, 1), mar = c(5, 4, 5) + 0.1, pin = c(3,3))
plot.vectorwavelet(result, plot.cb = TRUE, main = "Plot n-dimensional vwc (n=5)"

par(old.par)
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