Package 'vectorwavelet'

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Type Package

Title Vector Wavelet Coherence for Multiple Time Series

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Description New wavelet methodology (vector wavelet coherence) (Oygur, T., Unal, G, 2020 <doi:10.1007/s40435-020-00706-y>) 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

Suggests knitr, rmarkdown, devtools

Encoding UTF-8

LazyData TRUE

RoxygenNote 7.1.1

NeedsCompilation no

Repository CRAN

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R topics documented:

`vectorwavelet-package` *Vector wavelet coherence for multiple time series*

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)

Tunc Oygur, Gazanfer Unal

Maintainer: Tunc Oygur <info@tuncoygur.com.tr>

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

References

T. Oygur, G. Unal.. Vector wavelet coherence for multiple time series. *Int. J. Dynam. Control (2020).*

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.

Grinsted, A., J. C. Moore, and S. Jevrejeva. 2004. Application of the cross wavelet transform and wavelet coherence to geophysical time series. *Nonlinear Processes in Geophysics* 11:561-566.

Torrence, C., and G. P. Compo. 1998. A Practical Guide to Wavelet Analysis. *Bulletin of the American Meteorological Society* 79:61-78.

ar1nv *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

SGrinsted, A., J. C. Moore, and S. Jevrejeva. 2004. Application of the cross wavelet transform and wavelet coherence to geophysical time series. *Nonlinear Processes in Geophysics* 11:561-566.

mwc *Compute multiple wavelet coherence*

Description

Compute multiple wavelet coherence

Usage

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

Arguments

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.
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.
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.
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 χ^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 containg 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 containg `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

T. Oygur, G. Unal.. Vector wavelet coherence for multiple time series. *Int. J. Dynam. Control (2020).*

T. Oygur, G. Unal. 2017. 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*

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

```
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)
```

```
x1 <- cbind(t,x1)
x2 <- cbind(t,x2)

## Multiple wavelet coherence
result <- mwc(y, x1, x2, nrands = 10)

result <- mwc(y, x1, x2)


## 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 multiple wavelet coherence")

par(old.par)
```

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

#Example 2:
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

```
n.check.datum(x)
```

Arguments

x	matrix

Value

list(t, dt, n.obs)

Note

This function is not exported

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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. Sigificance contours will be drawn around all regions of the spectrum where spectrum/percentile >= tol. De-

	fault is 1. If strict i^{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 solide 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 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.

qmwc *Compute quadruple wavelet coherence*

Description

Compute quadruple wavelet coherence

Usage

```
qmwc(
  y,
  x1,
  x2,
  x3,
  pad = TRUE,
  dj = 1/12,
  s0 = 2 * dt,
  J1 = NULL,
  max.scale = NULL,
  mother = "morlet",
  param = -1,
  lag1 = NULL,
  sig.level = 0.95,
  sig.test = 0,
  nrands = 300,
  quiet = FALSE
)
```

Arguments

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.
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.
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.
x3	time series 4 in matrix format (m 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 χ^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 containg 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 containg sig.level percentiles of wavelet coherence based on the Monte Carlo AR(1) time series

Author(s)

Tunc Oygur (info@tuncoygur.com.tr)

References

T. Oygur, G. Unal.. Vector wavelet coherence for multiple time series. *Int. J. Dynam. Control (2020).*

T. Oygur, G. Unal. 2017. 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*

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/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

```
vwc(
  y,
  x,
  pad = TRUE,
  dj = 1/12,
  s0 = 2 * dt,
  J1 = NULL,
  max.scale = NULL,
  mother = "morlet",
  param = -1,
  lag1 = NULL,
```

```
  sig.level = 0.95,
  sig.test = 0,
  nrands = 300,
  quiet = FALSE
)
```

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 n columns). The first column should contain the time steps and the other columns 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 χ^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 containg 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 (vwc)
signif	matrix containg sig.level percentiles of wavelet coherence based on the Monte Carlo AR(1) time series

Author(s)

Tunc Oygur (info@tuncoygur.com.tr)

References

T. Oygur, G. Unal.. Vector wavelet coherence for multiple time series. *Int. J. Dynam. Control (2020).*

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, 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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