Package 'earlywarnings'

Type Package

Title Early Warning Signals Toolbox for Detecting Critical Transitions
in Timeseries

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Description The Early-Warning-Signals Toolbox provides methods for estimating
statistical changes in timeseries that can be used for identifying nearby
critical transitions. Based on Dakos et al (2012) Methods for Detecting
Early Warnings of Critical Transitions in Time Series Illustrated Using
Simulated Ecological Data. PLoS ONE 7(7):e41010

Depends R (>= 3.0.2), ggplot2, moments, tgp, tseries

Imports fields, nortest, quadprog, Kendall, KernSmooth, lmtest, som,
spam, stats

LazyLoad yes

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NeedsCompilation no

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R topics documented:

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bdstest_ews	*Description: BDS test Early Warning Signals*

Description

bdstest_ews is used to estimate the BDS statistic to detect nonlinearity in the residuals of a time-series after first-difference detrending, fitting an ARMA(p,q) model, and fitting a GARCH(0,1) model. The function is making use of bds.test from the tseries package.

Usage

```
bdstest_ews(timeseries, ARMAoptim = TRUE, ARMAorder = c(1, 0),
  GARCHorder = c(0, 1), embdim = 3, epsilon = c(0.5, 0.75, 1),
  boots = 1000, logtransform = FALSE, interpolate = FALSE)
```

Arguments

timeseries	a numeric vector of the observed univariate timeseries values or a numeric matrix where the first column represents the time index and the second the observed timeseries values. Use vectors/matrices with headings.
ARMAoptim	is the order of the ARMA(p,q) model to be fitted on the original timeseries. If TRUE the best ARMA model based on AIC is applied. If FALSE the ARMAorder is used.
ARMAorder	is the order of the AR(p) and MA(q) process to be fitted on the original timeseries. Default is p=1 q=0.
GARCHorder	fits a GARCH model on the original timeseries where GARCHorder[1] is the GARCH part and GARCHorder[2] is the ARCH part.
embdim	is the embedding dimension (2, 3,... embdim) up to which the BDS test will be estimated (must be numeric). Default value is 3.
epsilon	is a numeric vector that is used to scale the standard deviation of the timeseries. The BDS test is computed for each element of epsilon. Default is 0.5, 0.75 and 1.

boots	is the number of bootstraps performed to estimate significance p values for the BDS test. Default is 1000.
logtransform	logical. If TRUE data are logtransformed prior to analysis as log(X+1). Default is FALSE.
interpolate	logical. If TRUE linear interpolation is applied to produce a timeseries of equal length as the original. Default is FALSE (assumes there are no gaps in the timeseries).

Details

See also `bds.test{tseries}` for more details. The function requires the installation of packages `tseries` and `quadprog` that are not available under Linux and need to be manually installed under Windows.

Arguments:

Value

`bdstest_ews` returns output on the R console that summarizes the BDS test statistic for all embedding dimensions and `epsilon` values used, and for first-differenced data, ARMA(p.q) residuals, and GARCH(0,1) residuals). Also the significance p values are returned estimated both by comparing to a standard normal distribution and by bootstrapping.

In addition, `bdstest_ews` returns a plot with the original timeseries, the residuals after first-differencing, and fitting the ARMA(p,q) and GARCH(0,1) models. Also the autocorrelation [acf] and partial autocorrelation [pacf] functions are estimated serving as guides for the choice of lags of the linear models fitted to the data.

Author(s)

S. R. Carpenter, modified by V. Dakos

References

J. B. Cromwell, W. C. Labys and M. Terraza (1994): Univariate Tests for Time Series Models, Sage, Thousand Oaks, CA, pages 32-36.

Dakos, V., et al (2012).'Methods for Detecting Early Warnings of Critical Transitions in Time Series Illustrated Using Simulated Ecological Data.' *PLoS ONE* 7(7): e41010. doi:10.1371/journal.pone.0041010

See Also

[generic_ews]; [ddjnonparam_ews]; [bdstest_ews]; [sensitivity_ews]; [surrogates_ews]; [ch_ews]; [movpotential_ews]; [livpotential_ews]

Examples

```
#
data(foldbif)
bdstest_ews(foldbif,ARMAoptim=FALSE,ARMAorder=c(1,0),embdim=3,epsilon=0.5,
boots=200,logtransform=FALSE,interpolate=FALSE)
```

---

ch_ews   *Description: Conditional Heteroskedasticity*

Description

ch_ews is used to estimate changes in conditional heteroskedasticity within rolling windows along
a timeseries

Usage

```
ch_ews(timeseries, winsize = 10, alpha = 0.1, optim = TRUE, lags = 4,
  logtransform = FALSE, interpolate = FALSE)
```

Arguments

timeseries	a numeric vector of the observed timeseries values or a numeric matrix where the first column represents the time index and the second the observed timeseries values. Use vectors/matrices with headings.
winsize	is length of the rolling window expressed as percentage of the timeseries length (must be numeric between 0 and 100). Default is 10%.
alpha	is the significance threshold (must be numeric). Default is 0.1.
optim	logical. If TRUE an autoregressive model is fit to the data within the rolling window using AIC optimization. Otherwise an autoregressive model of specific order lags is selected.
lags	is a parameter that determines the specific order of an autoregressive model to fit the data. Default is 4.
logtransform	logical. If TRUE data are logtransformed prior to analysis as log(X+1). Default is FALSE.
interpolate	logical. If TRUE linear interpolation is applied to produce a timeseries of equal length as the original. Default is FALSE (assumes there are no gaps in the timeseries).

Details

see ref below

Arguments:

Value

ch_ews returns a matrix that contains:

time	the time index.
r.squared	the R2 values of the regressed residuals.
critical.value	the chi-square critical value based on the desired alpha level for 1 degree of freedom divided by the number of residuals used in the regression.

| test.result | logical. It indicates whether conditional heteroskedasticity was significant. |
| ar.fit.order | the order of the specified autoregressive model- only informative if optim FALSE was selected. |

In addition, ch_ews plots the original timeseries and the R2 where the level of significance is also indicated.

Author(s)

T. Cline, modified by V. Dakos

References

Seekell, D. A., et al (2011). 'Conditional heteroscedasticity as a leading indicator of ecological regime shifts.' *American Naturalist* 178(4): 442-451

Dakos, V., et al (2012).'Methods for Detecting Early Warnings of Critical Transitions in Time Series Illustrated Using Simulated Ecological Data.' *PLoS ONE* 7(7): e41010. doi:10.1371/journal.pone.0041010

See Also

generic_ews; ddjnonparam_ews; bdstest_ews; sensitivity_ews; surrogates_ews; ch_ews; movpotential_ews; livpotential_ews

Examples

```
data(foldbif)
out=ch_ews(foldbif, winsize=50, alpha=0.05, optim=TRUE, lags)
```

| circulation | *circulation data set* |

Description

circulation data set

Format

TBA

Source

TBA

References

See citation('earlywarnings')

Examples

```
#
```

---

ddjnonparam_ews	*Description: Drift Diffusion Jump Nonparametrics Early Warning Signals*

Description

ddjnonparam_ews is used to compute nonparametrically conditional variance, drift, diffusion and jump intensity in a timeseries. It also interpolates to obtain the evolution of the nonparametric statistics in time.

Usage

```
ddjnonparam_ews(timeseries, bandwidth = 0.6, na = 500,
  logtransform = TRUE, interpolate = FALSE)
```

Arguments

timeseries	a numeric vector of the observed univariate timeseries values or a numeric matrix where the first column represents the time index and the second the observed timeseries values. Use vectors/matrices with headings.
bandwidth	is the bandwidht of the kernel regressor (must be numeric). Default is 0.6.
na	is the number of points for computing the kernel (must be numeric). Default is 500.
logtransform	logical. If TRUE data are logtransformed prior to analysis as log(X+1). Default is FALSE.
interpolate	logical. If TRUE linear interpolation is applied to produce a timeseries of equal length as the original. Default is FALSE (assumes there are no gaps in the timeseries).

Details

The approach is based on estimating terms of a drift-diffusion-jump model as a surrogate for the unknown true data generating process: [1] $dx = f(x, \theta)dt + g(x, \theta)dW + dJ$ Here x is the state variable, f() and g() are nonlinear functions, dW is a Wiener process and dJ is a jump process. Jumps are large, one-step, positive or negative shocks that are uncorrelated in time.

Arguments:

Value

ddjnonparam_ews returns an object with elements:

avec	is the mesh for which values of the nonparametric statistics are estimated.
S2.vec	is the conditional variance of the timeseries x over avec.
TotVar.dx.vec	is the total variance of dx over avec.
Diff2.vec	is the diffusion estimated as total variance - jumping intensity vs avec.

`LamdaZ.vec`	is the jump intensity over avec.
`Tvec1`	is the timeindex.
`S2.t`	is the conditional variance of the timeseries x data over `Tvec1`.
`TotVar.t`	is the total variance of dx over `Tvec1`.
`Diff2.t`	is the diffusion over `Tvec1`.
`Lamda.t`	is the jump intensity over `Tvec1`.

In addition, `ddjnonparam_ews` returns a first plot with the original timeseries and the residuals after first-differencing. A second plot shows the nonparametric conditional variance, total variance, diffusion and jump intensity over the data, and a third plot the same nonparametric statistics over time.

Author(s)

S. R. Carpenter, modified by V. Dakos

References

Carpenter, S. R. and W. A. Brock (2011). 'Early warnings of unknown nonlinear shifts: a nonparametric approach.' *Ecology* 92(12): 2196-2201

Dakos, V., et al (2012).'Methods for Detecting Early Warnings of Critical Transitions in Time Series Illustrated Using Simulated Ecological Data.' *PLoS ONE* 7(7): e41010. doi:10.1371/journal.pone.0041010

See Also

generic_ews; ddjnonparam_ews; bdstest_ews; sensitivity_ews;surrogates_ews; ch_ews; movpotential_ews; livpotential_ews

Examples

```
data(foldbif)
output<-ddjnonparam_ews(foldbif,bandwidth=0.6,na=500,
logtransform=TRUE,interpolate=FALSE)
```

---

find.optima	*Description: find.optima*

Description

Detect optima, excluding very local optima below detection.threshold

Usage

```
find.optima(f, detection.threshold = 0, bw, x, detection.limit = 0)
```

Arguments

f   density

detection.threshold

                detection threshold for peaks

bw   bandwidth

x   original data

detection.limit

                ignore maxima that are below this value

                Returns:

Details

Arguments:

Value

A list with the following elements: min minima max maxima

Author(s)

Leo Lahti <leo.lahti@iki.fi>

References

See citation('TBA')

Examples

#

---

foldbif   *foldbif data set*

Description

foldbif data set

Format

TBA

Source

TBA

References

See citation('earlywarnings')

Examples

```
#
```

| generic_ews | *Description: Generic Early Warning Signals* |

Description

generic_ews is used to estimate statistical moments within rolling windows along a timeserie

Usage

```
generic_ews(timeseries, winsize = 50, detrending = c("no", "gaussian",
  "loess", "linear", "first-diff"), bandwidth = NULL, span = NULL,
  degree = NULL, logtransform = FALSE, interpolate = FALSE,
  AR_n = FALSE, powerspectrum = FALSE)
```

Arguments

timeseries	a numeric vector of the observed univariate timeseries values or a numeric matrix where the first column represents the time index and the second the observed timeseries values. Use vectors/matrices with headings. If the powerspectrum is to be plotted as well, the timeseries lenght should be even number.
winsize	is the size of the rolling window expressed as percentage of the timeseries length (must be numeric between 0 and 100). Default is 50%.
bandwidth	is the bandwidth used for the Gaussian kernel when gaussian filtering is applied. It is expressed as percentage of the timeseries length (must be numeric between 0 and 100). Alternatively it can be given by the bandwidth selector bw.nrd0 (Default).
detrending	the timeseries can be detrended/filtered prior to analysis. There are four options: gaussian filtering, loess fitting, linear detrending and first-differencing. Default is no detrending.
span	parameter that controls the degree of smoothing (numeric between 0 and 100, Default 25). see more on loessstats
degree	the degree of polynomial to be used for when loess fitting is applied, normally 1 or 2 (Default). see more on loessstats
logtransform	logical. If TRUE data are logtransformed prior to analysis as log(X+1). Default is FALSE.
interpolate	logical. If TRUE linear interpolation is applied to produce a timeseries of equal length as the original. Default is FALSE (assumes there are no gaps in the timeseries).

| AR_n | logical. If TRUE the best fitted AR(n) model is fitted to the data. Default is FALSE. |
| powerspectrum | logical. If TRUE the power spectrum within each rolling window is plotted. Default is FALSE. |

Details

see ref below

Value

generic_ews returns a matrix that contains:

tim	the time index.
ar1	the autoregressive coefficient ar(1) of a first order AR model fitted on the data within the rolling window.
sd	the standard deviation of the data estimated within each rolling window.
sk	the skewness of the data estimated within each rolling window.
kurt	the kurtosis of the data estimated within each rolling window.
cv	the coefficient of variation of the data estimated within each rolling window.
returnrate	the return rate of the data estimated as 1-ar(1) cofficient within each rolling window.
densratio	the density ratio of the power spectrum of the data estimated as the ratio of low frequencies over high frequencies within each rolling window.
acf1	the autocorrelation at first lag of the data estimated within each rolling window.

In addition, generic_ews returns three plots. The first plot contains the original data, the detrending/filtering applied and the residuals (if selected), and all the moment statistics. For each statistic trends are estimated by the nonparametric Kendall tau correlation. The second plot, if asked, quantifies resilience indicators fitting AR(n) selected by the Akaike Information Criterion. The third plot, if asked, is the power spectrum estimated by spec.ar for all frequencies within each rolling window.

Author(s)

Vasilis Dakos <vasilis.dakos@gmail.com>

References

Ives, A. R. (1995). 'Measuring resilience in stochastic systems.' *Ecological Monographs* 65: 217-233

Dakos, V., et al (2008). 'Slowing down as an early warning signal for abrupt climate change.' *Proceedings of the National Academy of Sciences* 105(38): 14308-14312

Dakos, V., et al (2012).'Methods for Detecting Early Warnings of Critical Transitions in Time Series Illustrated Using Simulated Ecological Data.' *PLoS ONE* 7(7): e41010. doi:10.1371/journal.pone.0041010

See Also

generic_ews; ddjnonparam_ews; bdstest_ews; sensitivity_ews; surrogates_ews; ch_ews; movpotential_ews; livpotential_ews;

Examples

```
data(foldbif)
out=generic_ews(foldbif,winsize=50,detrending='gaussian',
bandwidth=5,logtransform=FALSE,interpolate=FALSE)
```

---

livpotential_ews	*Description: Potential Analysis for univariate data*

Description

livpotential_ews performs one-dimensional potential estimation derived from a uni-variate time-series

Usage

```
livpotential_ews(x, std = 1, bw = "nrd", weights = c(),
  grid.size = NULL, detection.threshold = 0.01, bw.adjust = 1,
  density.smoothing = 0, detection.limit = 0.1)
```

Arguments

x	Univariate data (vector) for which the potentials shall be estimated
std	Standard deviation of the noise (defaults to 1; this will set scaled potentials)
bw	bandwidth for kernel estimation
weights	optional weights in ksdensity (used by movpotentials).
grid.size	Grid size for potential estimation.
detection.threshold	
	maximum detection threshold as fraction of density kernel height dnorm(0, sd = bandwidth)/N
bw.adjust	The real bandwidth will be bw.adjust*bw; defaults to 1
density.smoothing	
	Add a small constant density across the whole observation range to regularize density estimation (and to avoid zero probabilities within the observation range). This parameter adds uniform density across the observation range, scaled by density.smoothing.
detection.limit	
	ignore maxima that are below detection.limit * maximum density

Details

Arguments:

Value

`livpotential` returns a list with the following elements:

xi	the grid of points on which the potential is estimated
pot	The estimated potential: -log(f)*std^2/2, where f is the density.
density	Density estimate corresponding to the potential.
min.inds	indices of the grid points at which the density has minimum values; (-potentials; neglecting local optima)
max.inds	indices the grid points at which the density has maximum values; (-potentials; neglecting local optima)
bw	bandwidth of kernel used
min.points	grid point values at which the density has minimum values; (-potentials; neglecting local optima)
max.points	grid point values at which the density has maximum values; (-potentials; neglecting local optima)

Author(s)

Based on Matlab code from Egbert van Nes modified by Leo Lahti. Implemented in early warnings package by V. Dakos.

References

Livina, VN, F Kwasniok, and TM Lenton, 2010. Potential analysis reveals changing number of climate states during the last 60 kyr . *Climate of the Past*, 6, 77-82.

Dakos, V., et al (2012).'Methods for Detecting Early Warnings of Critical Transitions in Time Series Illustrated Using Simulated Ecological Data.' *PLoS ONE* 7(7): e41010. doi:10.1371/journal.pone.0041010

See Also

generic_ews; ddjnonparam_ews; bdstest_ews; sensitivity_ews;surrogates_ews; ch_ews;movpotential_ews

Examples

```
data(foldbif)
res <- livpotential_ews(foldbif)
```

---

movpotential_ews   *Moving Average Potential*

Description

This function reconstructs a potential derived from data along a gradient of a given parameter.

Usage

```
movpotential_ews(X, param = NULL, bw = "nrd", bw.adjust = 1,
  detection.threshold = 0.1, std = 1, grid.size = 50, plot.cutoff = 0.5,
  plot.contours = TRUE, binwidth = 0.2, bins = NULL)
```

Arguments

X	a vector of the X observations of the state variable of interest
param	parameter values corresponding to the observations in X
bw	Bandwidth for smoothing kernels. Automatically determined by default.
bw.adjust	Bandwidth adjustment constant
detection.threshold	
	Threshold for local optima to be discarded.
std	Standard deviation.
grid.size	number of evaluation points; number of steps between min and max potential; also used as kernel window size
plot.cutoff	cuttoff for potential minima and maxima in visualization
plot.contours	Plot contours on the landscape visualization
binwidth	binwidth for contour plot
bins	bins for contour plot. Overrides binwidth if given

Details

Arguments:

Value

A list with the following elements: pars values of the covariate parameter as matrix; xis values of the x as matrix; pots smoothed potentials; mins minima in the densities (-potentials; neglecting local optima); maxs maxima in densities (-potentials; neglecting local optima); plot an object that displays the potential estimated in 2D

Author(s)

L. Lahti, E. van Nes, V. Dakos.

References

Hirota, M., Holmgren, M., van Nes, E.H. & Scheffer, M. (2011). Global resilience of tropical forest and savanna to critical transitions. *Science*, 334, 232-235.

See Also

[generic_ews](); [ddjnonparam_ews](); [bdstest_ews](); [sensitivity_ews]();[surrogates_ews](); [ch_ews](); livpotential_ews

Examples

```
X = c(rnorm(1000, mean = 0), rnorm(1000, mean = -2), rnorm(1000, mean = 2));
param = seq(0,5,length=3000);
res <- movpotential_ews(X, param)
```

PlotPotential   *Description: Plot Potential*

Description

Visualization of the potential function from the movpotential function

Usage

```
PlotPotential(res, title = "", xlab.text, ylab.text, cutoff = 0.5,
  plot.contours = TRUE, binwidth = 0.2, bins = NULL)
```

Arguments

res	output from movpotential function
title	title text
xlab.text	xlab text
ylab.text	ylab text
cutoff	parameter determining the upper limit of potential for visualizations
plot.contours	Plot contour lines.
binwidth	binwidth for contour plot
bins	bins for contour plot. Overrides binwidth if given

Details

Arguments:

Value

ggplot2	potential plotted

Author(s)

Leo Lahti <leo.lahti@iki.fi>

References

Dakos, V., et al (2012).'Methods for Detecting Early Warnings of Critical Transitions in Time Series Illustrated Using Simulated Ecological Data.' *PLoS ONE* 7(7): e41010. doi:10.1371/journal.pone.0041010

Examples

```
X = c(rnorm(1000, mean = 0), rnorm(1000, mean = -2), rnorm(1000, mean = 2));
param = seq(0,5,length=3000); res <- movpotential_ews(X, param);
PlotPotential(res$res, title = '', xlab.text = '', ylab.text = '',
cutoff = 0.5, plot.contours = TRUE, binwidth = 0.2)
```

---

qda_ews	*Description: Quick Detection Analysis for Generic Early Warning Signals*

Description

qda_ews is used to estimate autocorrelation, variance within rolling windows along a timeseries, test the significance of their trends, and reconstruct the potential landscape of the timeseries

Usage

```
qda_ews(timeseries, param = NULL, winsize = 50, detrending = c("no",
  "gaussian", "linear", "first-diff"), bandwidth = NULL, boots = 100,
  s_level = 0.05, cutoff = 0.05, detection.threshold = 0.002,
  grid.size = 50, logtransform = FALSE, interpolate = FALSE)
```

Arguments

timeseries	a numeric vector of the observed univariate timeseries values or a numeric matrix where the first column represents the time index and the second the observed timeseries values. Use vectors/matrices with headings.
param	values corresponding to observations in timeseries
winsize	is the size of the rolling window expressed as percentage of the timeseries length (must be numeric between 0 and 100). Default is 50%.
detrending	the timeseries can be detrended/filtered prior to analysis. There are four options: gaussian filtering, linear detrending and first-differencing. Default is no detrending.
bandwidth	is the bandwidth used for the Gaussian kernel when gaussian filtering is applied. It is expressed as percentage of the timeseries length (must be numeric between 0 and 100). Alternatively it can be given by the bandwidth selector bw.nrd0 (Default).

boots	the number of surrogate data to generate from fitting an ARMA(p,q) model. Default is 100.
s_level	significance level. Default is 0.05.
cutoff	the cutoff value to visualize the potential landscape
detection.threshold	
	detection threshold for potential minima
grid.size	grid size (for potential analysis)
logtransform	logical. If TRUE data are logtransformed prior to analysis as log(X+1). Default is FALSE.
interpolate	logical. If TRUE linear interpolation is applied to produce a timeseries of equal length as the original. Default is FALSE (assumes there are no gaps in the timeseries).
	qda_ews produces three plots. The first plot contains the original data, the detrending/filtering applied and the residuals (if selected), autocorrelation and variance. For each statistic trends are estimated by the nonparametric Kendall tau correlation. The second plot, returns a histogram of the distributions of the Kendall trend statistic for autocorrelation and variance estimated on the surrogated data. Vertical lines represent the level of significance, whereas the black dots the actual trend found in the time series. The third plot is the reconstructed potential landscape in 2D. In addition, the function returns a list containing the output from the respective functions generic_RShiny (indicators); surrogates_RShiny (trends); movpotential_ews (potential analysis)

Details

see ref below

Arguments:

Author(s)

Vasilis Dakos, Leo Lahti, March 1, 2013 <vasilis.dakos@gmail.com>

References

Dakos, V., et al (2012).'Methods for Detecting Early Warnings of Critical Transitions in Time Series Illustrated Using Simulated Ecological Data.' *PLoS ONE* 7(7): e41010. doi:10.1371/journal.pone.0041010

See Also

generic_ews; ddjnonparam_ews; bdstest_ews; sensitivity_ews; surrogates_ews; ch_ews; movpotential_ews; livpotential_ews;

Examples

```
data(foldbif)
out <- qda_ews(foldbif, param = NULL, winsize = 50, detrending='gaussian', bandwidth=NULL,
boots = 50, s_level = 0.05, cutoff=0.05, detection.threshold = 0.002, grid.size = 50,
logtransform=FALSE, interpolate=FALSE)
```

---

sensitivity_ews   *Description: Sensitivity Early Warning Signals*

Description

sensitivity_ews is used to estimate trends in statistical moments for different sizes of rolling windows along a timeseries. The trends are estimated by the nonparametric Kendall tau correlation coefficient.

Usage

```
sensitivity_ews(timeseries, indicator = c("ar1", "sd", "acf1", "sk", "kurt",
  "cv", "returnrate", "densratio"), winsizerange = c(25, 75),
  incrwinsize = 25, detrending = c("no", "gaussian", "loess", "linear",
  "first-diff"), bandwidthrange = c(5, 100), spanrange = c(5, 100),
  degree = NULL, incrbandwidth = 20, incrspanrange = 10,
  logtransform = FALSE, interpolate = FALSE)
```

Arguments

timeseries	a numeric vector of the observed univariate timeseries values or a numeric matrix where the first column represents the time index and the second the observed timeseries values. Use vectors/matrices with headings.
indicator	is the statistic (leading indicator) selected for which the sensitivity analysis is perfomed. Currently, the indicators supported are: ar1 autoregressive coefficient of a first order AR model, sd standard deviation, acf1 autocorrelation at first lag, sk skewness, kurt kurtosis, cv coeffcient of variation, returnrate, and densratio density ratio of the power spectrum at low frequencies over high frequencies.
winsizerange	is the range of the rolling window sizes expressed as percentage of the timeseries length (must be numeric between 0 and 100). Default is 25% - 75%.
incrwinsize	increments the rolling window size (must be numeric between 0 and 100). Default is 25.
detrending	the timeseries can be detrended/filtered. There are three options: gaussian filtering, loess fitting, linear detrending and first-differencing. Default is no detrending.
bandwidthrange	is the range of the bandwidth used for the Gaussian kernel when gaussian filtering is selected. It is expressed as percentage of the timeseries length (must be numeric between 0 and 100). Default is 5% - 100%.
spanrange	parameter that controls the degree of smoothing (numeric between 0 and 100). Default is 5% - 100%. see more on loessstats
degree	the degree of polynomial to be used for when loess fitting is applied, normally 1 or 2 (Default). see more on loessstats

incrbandwidth	is the size to increment the bandwidth used for the Gaussian kernel when gaussian filtering is applied. It is expressed as percentage of the timeseries length (must be numeric between 0 and 100). Default is 20.
incrspanrange	Span range
logtransform	logical. If TRUE data are logtransformed prior to analysis as log(X+1). Default is FALSE.
interpolate	logical. If TRUE linear interpolation is applied to produce a timeseries of equal length as the original. Default is FALSE (assumes there are no gaps in the timeseries).

Details

see ref below

Arguments:

Value

`sensitivity_ews` returns a matrix that contains the Kendall tau rank correlation estimates for the rolling window sizes (rows) and bandwidths (columns), if gaussian filtering is selected.

In addition, `sensitivity_ews` returns a plot with the Kendall tau estimates and their p-values for the range of rolling window sizes used, together with a histogram of the distributions of the statistic and its significance. When gaussian filtering is chosen, a contour plot is produced for the Kendall tau estimates and their p-values for the range of both rolling window sizes and bandwidth used. A reverse triangle indicates the combination of the two parameters for which the Kendall tau was the highest

Author(s)

Vasilis Dakos <vasilis.dakos@gmail.com>

References

Dakos, V., et al (2008). 'Slowing down as an early warning signal for abrupt climate change.' *Proceedings of the National Academy of Sciences* 105(38): 14308-14312

Dakos, V., et al (2012).'Methods for Detecting Early Warnings of Critical Transitions in Time Series Illustrated Using Simulated Ecological Data.' *PLoS ONE* 7(7): e41010. doi:10.1371/journal.pone.0041010

See Also

generic_ews; ddjnonparam_ews; bdstest_ews; sensitivity_ews; surrogates_ews; ch_ews; movpotential_ews; livpotential_ews

Examples

```
data(foldbif)
output=sensitivity_ews(foldbif,indicator='sd',detrending='gaussian',
incrwinsize=25,incrbandwidth=20)
```

---

surrogates_ews   *Description: Surrogates Early Warning Signals*

Description

surrogates_ews is used to estimate distributions of trends in statistical moments from different
surrogate timeseries generated after fitting an ARMA(p,q) model on the data. The trends are esti-
mated by the nonparametric Kendall tau correlation coefficient and can be compared to the trends
estimated in the original timeseries to produce probabilities of false positives.

Usage

```
surrogates_ews(timeseries, indicator = c("ar1", "sd", "acf1", "sk", "kurt",
  "cv", "returnrate", "densratio"), winsize = 50, detrending = c("no",
  "gaussian", "loess", "linear", "first-diff"), bandwidth = NULL,
  span = NULL, degree = NULL, boots = 100, logtransform = FALSE,
  interpolate = FALSE)
```

Arguments

timeseries	a numeric vector of the observed univariate timeseries values or a numeric ma-trix where the first column represents the time index and the second the observed timeseries values. Use vectors/matrices with headings.
indicator	is the statistic (leading indicator) selected for which the surrogate timeseries are produced. Currently, the indicators supported are: ar1 autoregressive coefficient of a first order AR model, sd standard deviation, acf1 autocorrelation at first lag, sk skewness, kurt kurtosis, cv coeffcient of variation, returnrate, and densratio density ratio of the power spectrum at low frequencies over high frequencies.
winsize	is the size of the rolling window expressed as percentage of the timeseries length (must be numeric between 0 and 100). Default valuise 50%.
detrending	the timeseries can be detrended/filtered prior to analysis. There are three op-tions: gaussian filtering, loess fitting, linear detrending and first-differencing. Default is no detrending.
bandwidth	is the bandwidth used for the Gaussian kernel when gaussian filtering is selected. It is expressed as percentage of the timeseries length (must be numeric between 0 and 100). Alternatively it can be given by the bandwidth selector bw.nrd0 (Default).
span	parameter that controls the degree of smoothing (numeric between 0 and 100, Default 25). see more on loessstats
degree	the degree of polynomial to be used for when loess fitting is applied, normally 1 or 2 (Default). see more on loessstats
boots	the number of surrogate data. Default is 100.
logtransform	logical. If TRUE data are logtransformed prior to analysis as log(X+1). Default is FALSE.

interpolate   logical. If TRUE linear interpolation is applied to produce a timeseries of equal
                     length as the original. Default is FALSE (assumes there are no gaps in the
                     timeseries).

Details

see ref below

Arguments:

Value

surrogates_ews returns a matrix that contains:

Kendall tau estimate original
                     the trends of the original timeseries.
Kendall tau p-value original
                     the p-values of the trends of the original timeseries.
Kendall tau estimate surrogates
                     the trends of the surrogate timeseries.
Kendall tau p-value surrogates
                     the associated p-values of the trends of the surrogate timeseries.
significance p   the p-value for the original Kendall tau rank correlation estimate compared to
                     the surrogates.

In addition, surrogates_ews returns a plot with the distribution of the surrogate Kendall tau esti-
mates and the Kendall tau estimate of the original series. Vertical lines indicate the 5% and 95%
significance levels.

Author(s)

Vasilis Dakos <vasilis.dakos@gmail.com>

References

Dakos, V., et al (2008). 'Slowing down as an early warning signal for abrupt climate change.'
Proceedings of the National Academy of Sciences 105(38): 14308-14312

Dakos, V., et al (2012).'Methods for Detecting Early Warnings of Critical Transitions in Time Series
Illustrated Using Simulated Ecological Data.' *PLoS ONE* 7(7): e41010. doi:10.1371/journal.pone.0041010

See Also

generic_ews; ddjnonparam_ews; bdstest_ews; sensitivity_ews; surrogates_ews; ch_ews;
movpotential_ews; livpotential_ews

Examples

```
data(foldbif)
output=surrogates_ews(foldbif,indicator='sd',winsize=50,detrending='gaussian',
bandwidth=10,boots=200,logtransform=FALSE,interpolate=FALSE)
```

UnivariateGrouping   *Description: Get group assigment indices for univariate data points, given cluster break points*

Description

Arguments:

Usage

```
UnivariateGrouping(x, breakpoints)
```

Arguments

x   Univariate data vector

breakpoints   Cluster breakpoints
                   Returns:

Value

A vector of cluster indices

Author(s)

Leo Lahti <leo.lahti@iki.fi>

Examples

```
#
```

YD2PB_grayscale   *YD2PB_grayscale data set*

Description

YD2PB_grayscale data set

Format

TBA

Source

TBA

References

See citation('earlywarnings')

Examples

\#

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