Package 'xiacf'

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Type Package

Title Nonlinear Dependence and Lead-Lag Analysis via Chatterjee's Xi

Version 0.5.0

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Description Computes Chatterjee's non-parametric correlation coefficient for time series data. It extends the original metric to time series analysis by providing the Xi-Autocorrelation Function (Xi-ACF) and Xi-Cross-Correlation Function (Xi-CCF). The package allows users to test for non-linear dependence using Iterative Amplitude Adjusted Fourier Transform (IAAFT) surrogate data with strict Family-Wise Error Rate ('FWER') control via Max-statistic approaches. Methodologies are based on Chatterjee (2021) <doi:10.1080/01621459.2020.1758115> and surrogate data testing methods by Schreiber and Schmitz (1996) <doi:10.1103/PhysRevLett.77.635>.

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Imports dplyr (>= 1.1.4), doFuture, foreach, future, ggplot2 (>= 4.0.1), patchwork, progressr, Rcpp (>= 1.1.0), stats

LinkingTo Rcpp, RcppArmadillo

RoxygenNote 7.3.3

Suggests testthat (>= 3.3.2)

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NeedsCompilation yes

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`autoplot.xi_acf` *Plot method for xi_acf objects*

Description

Plot method for xi_acf objects

Usage

```
## S3 method for class 'xi_acf'
autoplot(object, ...)
```

Arguments

`object`	An object of class `xi_acf`.
`...`	Additional arguments passed to other methods.

`autoplot.xi_ccf` *Plot method for xi_ccf objects*

Description

Plot method for xi_ccf objects

Usage

```
## S3 method for class 'xi_ccf'
autoplot(object, ...)
```

Arguments

`object`	An object of class `xi_ccf`.
`...`	Additional arguments passed to other methods.

autoplot.xi_matrix *Plot method for xi_matrix objects*

Description

Plot method for xi_matrix objects

Usage

```
## S3 method for class 'xi_matrix'
autoplot(object, ...)
```

Arguments

object	An object of class xi_matrix.
...	Additional arguments passed to other methods.

extract_xi_acf *Extract Individual Xi-ACF from a Multivariate Xi-Matrix*

Description

Extract Individual Xi-ACF from a Multivariate Xi-Matrix

Usage

```
extract_xi_acf(object, var, x_raw = NULL)
```

Arguments

object	An object of class xi_matrix.
var	A character string specifying the variable name.
x_raw	Optional. The original data to calculate linear ACF.

Value

An object of class xi_acf.

extract_xi_ccf *Extract Pairwise Xi-CCF from a Multivariate Xi-Matrix*

Description

Extract Pairwise Xi-CCF from a Multivariate Xi-Matrix

Usage

```
extract_xi_ccf(object, var_x, var_y, x_raw = NULL)
```

Arguments

object	An object of class xi_matrix.
var_x	Variable X name.
var_y	Variable Y name.
x_raw	Optional. The original data to calculate linear CCF.

Value

An object of class xi_ccf.

print.xi_matrix *Print method for xi_matrix*

Description

Print method for xi_matrix

Usage

```
## S3 method for class 'xi_matrix'
print(x, ...)
```

Arguments

x	An object of class xi_matrix.
...	Additional arguments passed to print.

Value

The original object x invisibly.

`run_rolling_xi_acf` *Rolling Xi-ACF Analysis*

Description

Performs a rolling window analysis using Chatterjee's Xi coefficient to assess the time-varying non-linear dependence structure of a time series with FWER control.

Usage

```
run_rolling_xi_acf(
  x,
  time_index = NULL,
  window_size,
  step_size = 1,
  max_lag,
  n_surr = 399,
  sig_level = 0.05,
  n_cores = NULL,
  save_dir = NULL
)
```

Arguments

`x`	A numeric vector representing the time series.
`time_index`	Optional vector of timestamps.
`window_size`	An integer specifying the size of the rolling window.
`step_size`	An integer specifying the step size. Default is 1.
`max_lag`	An integer specifying the maximum lag.
`n_surr`	An integer specifying the number of IAAFT surrogate datasets. Default is 399.
`sig_level`	A numeric value specifying the significance level (FWER). Default is 0.05.
`n_cores`	An integer specifying the number of cores for parallel execution.
`save_dir`	A character string specifying the directory path to save intermediate results.

Value

A `data.frame` containing the rolling window results.

`run_rolling_xi_ccf` *Rolling Directional Xi-CCF Analysis*

Description

Performs a rolling window analysis using Chatterjee's Xi cross-correlation to assess the time-varying non-linear lead-lag relationship between two time series with FWER control.

Usage

```
run_rolling_xi_ccf(
  x,
  y,
  time_index = NULL,
  window_size,
  step_size = 1,
  max_lag,
  n_surr = 399,
  sig_level = 0.05,
  n_cores = NULL,
  save_dir = NULL
)
```

Arguments

`x`	A numeric vector representing the first time series (predictor/lead candidate).
`y`	A numeric vector representing the second time series (response/lag candidate).
`time_index`	Optional vector of timestamps.
`window_size`	An integer specifying the size of the rolling window.
`step_size`	An integer specifying the step size. Default is 1.
`max_lag`	An integer specifying the maximum positive lag to compute.
`n_surr`	An integer specifying the number of MIAAFT surrogate datasets. Default is 399.
`sig_level`	A numeric value specifying the significance level (FWER). Default is 0.05.
`n_cores`	An integer specifying the number of cores for parallel execution.
`save_dir`	A character string specifying the directory path to save intermediate results.

Value

A `data.frame` containing the rolling window results.

surrogate_iaaft_cpp *Generate Multiple IAAFT Surrogates (Univariate)*

Description

Generate Multiple IAAFT Surrogates (Univariate)

Usage

```
surrogate_iaaft_cpp(x, n_surr, max_iter = 100L)
```

Arguments

x	A numeric vector.
n_surr	Number of surrogates to generate.
max_iter	Maximum iterations for IAAFT.

Value

A matrix of surrogates (N x n_surr).

surrogate_miaaft_cpp *Generate Multiple MIAAFT Surrogates (3D Array / Cube)*

Description

Generate Multiple MIAAFT Surrogates (3D Array / Cube)

Usage

```
surrogate_miaaft_cpp(X, n_surr, max_iter = 100L)
```

Arguments

X	A numeric matrix (N x p).
n_surr	Number of surrogates to generate.
max_iter	Maximum iterations for MIAAFT.

Value

A 3D array (arma::cube) of dimensions N x p x n_surr.

xiacf-deprecated *Deprecated functions in xiacf*

Description

These functions are provided for backward compatibility with older versions of xiacf and will be removed in future releases.

Usage

```
xi_test(x, max_lag = 10, n_surr = 399, sig_level = 0.95, max_iter = 100, ...)

generate_iaaft_surrogate(...)

generate_miaaft_surrogates(...)

generate_miaaft_surrogate_cpp(...)

run_rolling_xi_analysis(...)

compute_xi_acf_iaaft(...)

compute_xi_ccf_miaaft(...)

compute_xi_matrix_miaaft(...)
```

Arguments

x	A numeric vector or matrix depending on the function.
max_lag	An integer specifying the maximum lag.
n_surr	An integer specifying the number of surrogate datasets.
sig_level	A numeric value specifying the significance or confidence level.
max_iter	An integer specifying the maximum iterations.
...	Additional arguments passed to the updated functions.

xi_acf *Compute empirical Xi-ACF and its significance via IAAFT surrogates*

Description

Compute empirical Xi-ACF and its significance via IAAFT surrogates

Usage

```
xi_acf(x, max_lag = 10, n_surr = 399, sig_level = 0.05, max_iter = 100, ...)

## S3 method for class 'xi_acf'
print(x, ...)
```

Arguments

x	A numeric vector representing the time series data. Must not contain missing values (NA) or be a constant.
max_lag	An integer specifying the maximum lag to compute. Default is 10.
n_surr	An integer specifying the number of surrogate datasets to generate. Default is 399.
sig_level	A numeric value between 0 and 1 specifying the significance level. Default is 0.05.
max_iter	An integer specifying the maximum iterations for the IAAFT algorithm. Default is 100.
...	Additional arguments (currently ignored).

Value

An object of class `xi_acf` containing the empirical ACF, pointwise thresholds, global threshold, and metadata.

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xi_ccf *Directional Xi-CCF Test for Bivariate Time Series*

Description

Computes the empirical Cross-Correlation Function (CCF) based on Chatterjee's Xi, and evaluates its statistical significance using MIAAFT surrogates.

Usage

```
xi_ccf(x, y, max_lag = 10, n_surr = 399, sig_level = 0.05, max_iter = 100, ...)

## S3 method for class 'xi_ccf'
print(x, ...)
```

Arguments

x	A numeric vector. Must not contain missing values (NA) or be a constant.
y	A numeric vector of the same length as x. Must not contain missing values or be a constant.
max_lag	An integer specifying the maximum lag. Default is 10.

n_surr	An integer specifying the number of MIAAFT surrogate datasets to generate. Default is 399.
sig_level	A numeric value between 0 and 1 specifying the significance level for FWER control. Default is 0.05.
max_iter	An integer specifying the maximum iterations for the MIAAFT algorithm. Default is 100.
...	Additional arguments.

Value

An object of class "xi_ccf" containing the empirical correlations and Max-statistic thresholds.

---

xi_coefficient *Compute Chatterjee's Xi coefficient (Exported to R)*

Description

Compute Chatterjee's Xi coefficient (Exported to R)

Usage

```
xi_coefficient(x, y)
```

Arguments

x	A numeric vector.
y	A numeric vector.

Value

The Xi coefficient.

---

xi_matrix *Multivariate Xi-Correlogram Matrix*

Description

Computes the pairwise directional Chatterjee's Xi coefficient for a multivariate time series.

Usage

```
xi_matrix(x, max_lag = 10, n_surr = 399, sig_level = 0.05, max_iter = 100, ...)
```

Arguments

x	A numeric matrix or data.frame containing the multivariate time series (columns = variables).
max_lag	An integer specifying the maximum positive lag to compute. Default is 10.
n_surr	An integer specifying the number of MIAAFT surrogate datasets. Default is 399.
sig_level	A numeric value between 0 and 1 specifying the significance level. Default is 0.05.
max_iter	An integer specifying the maximum iterations for the MIAAFT algorithm. Default is 100.
...	Additional arguments.

Value

An S3 object of class `xi_matrix` containing a tidy data frame of pairwise results.

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