# Package 'xiacf'

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**Type** Package

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

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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 univariate Xi-Autocorrelation Function (Xi-ACF), directional Xi-Cross-Correlation Function (Xi-CCF), and multivariate network evaluation matrices. The package allows users to test for nonlinear dependence using Iterative Amplitude Adjusted Fourier Transform (IAAFT) and Multivariate IAAFT (MIAAFT) 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>, surrogate data testing methods by Schreiber and Schmitz (1996) <doi:10.1103/PhysRevLett.77.635>, and local structural identification by Watanabe (2026) <doi:10.2139/ssrn.6829431>.

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**Encoding** UTF-8

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

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## 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 Univariate Xi-ACF from a Multivariate Xi-Matrix*

### Description

Extract Univariate Xi-ACF from a Multivariate Xi-Matrix

### Usage

```
extract_xi_acf(obj, var, ...)
```

### Arguments

| | |
|---|---|
| obj | An object of class xi_matrix. |
| var | A character string specifying the variable name to extract. |
| ... | Additional arguments passed to xi_acf. |

### Value

An object of class xi_acf. #' @note This function performs a fresh re-calculation of the surrogate data distribution specifically for the targeted variables. As a result, two differences from the original matrix output should be expected: 1. **FWER Recalibration:** The global threshold will be recalibrated for the bivariate (or univariate) case, typically making it less conservative and restoring statistical power for the specific pathway. 2. **Monte Carlo Variation:** Due to the randomized nature of surrogate data generation, slight numerical variations in the thresholds and confidence intervals may occur unless a random seed is explicitly set (e.g., 'set.seed()') immediately prior to calling this extraction function.

## extract_xi_ccf *Extract Bivariate Xi-CCF from a Multivariate Xi-Matrix*

### Description

Extract Bivariate Xi-CCF from a Multivariate Xi-Matrix

### Usage

```
extract_xi_ccf(obj, var_x, var_y, ...)
```

### Arguments

| | |
|---|---|
| obj | An object of class xi_matrix. |
| var_x | A character string specifying the lead variable. |
| var_y | A character string specifying the lag variable. |
| ... | Additional arguments passed to xi_ccf. |

## Value

An object of class `xi_ccf`. #' @note This function performs a fresh re-calculation of the surrogate data distribution specifically for the targeted variables. As a result, two differences from the original matrix output should be expected: 1. **FWER Recalibration:** The global threshold will be recalibrated for the bivariate (or univariate) case, typically making it less conservative and restoring statistical power for the specific pathway. 2. **Monte Carlo Variation:** Due to the randomized nature of surrogate data generation, slight numerical variations in the thresholds and confidence intervals may occur unless a random seed is explicitly set (e.g., 'set.seed()') immediately prior to calling this extraction function.

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# `print.xi_ccf` *Print method for xi_ccf*

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## Description

Print method for xi_ccf

## Usage

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

## Arguments

| | |
|---|---|
| `x` | An object of class `xi_ccf`. |
| `...` | Additional arguments passed to print. |

## Value

The original object `x` invisibly.

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# `print.xi_matrix` *Print method for xi_matrix*

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## 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.

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## run_rolling_xi_acf *Rolling Window Analysis for Xi-ACF*

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### Description

Rolling Window Analysis for Xi-ACF

### 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 data. |
| time_index | An optional vector representing 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 to compute. |
| 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. |
| `y` | A numeric vector representing the second time series. |
| `time_index` | An optional vector representing 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 *Bivariate Xi-Cross-Correlation Function*

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### Description

Computes the directional Chatterjee's Xi coefficient between two time series across multiple lags, with Family-Wise Error Rate (FWER) control.

### Usage

```
xi_ccf(
  x,
  y,
  max_lag = 20,
  n_surr = 399,
  sig_level = 0.05,
  max_iter = 100,
  direction = c("both", "x_leads"),
  ...
)
```

### Arguments

| | |
|---|---|
| x | A numeric vector representing the first time series. |
| y | A numeric vector representing the second time series. |
| max_lag | An integer specifying the maximum lag to compute. Default is 20. |
| 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. |
| max_iter | An integer specifying the maximum iterations for the MIAAFT algorithm. Default is 100. |
| direction | A character string specifying the testing direction. "both" computes X->Y and Y->X. "x_leads" computes only X->Y. Default is "both". |
| ... | Additional arguments. |

### Value

An S3 object of class `xi_ccf`.

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

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### 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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