# Package ‘tseriesChaos’

January 7, 2019

**Title** Analysis of Nonlinear Time Series

**Date** 2013-04-29

**Version** 0.1-13.1

**Author** Antonio, Fabio Di Narzo

**Depends** R (>= 2.2.0)

**Imports** deSolve

**Suggests** scatterplot3d

**LazyData** yes

**LazyLoad** yes

**Description** Routines for the analysis of nonlinear time series. This work is largely inspired by the TISEAN project, by Rainer Hegger, Holger Kantz and Thomas Schreiber: <http://www.mpipks-dresden.mpg.de/~tisean/>.

**Maintainer** Antonio Fabio Di Narzo <antonio.fabio@gmail.com>

**License** GPL-2

**Repository** CRAN

**Date/Publication** 2019-01-07 12:21:28 UTC

**NeedsCompilation** yes

## R topics documented:

---

`C2` *Sample correlation integral*

---

## Description

Sample correlation integral for the specified length scale

## Usage

```
C2(series, m, d, t, eps)
```

## Arguments

| | |
|---|---|
| `series` | time series |
| `m` | embedding dimension |
| `d` | time delay |
| `t` | Theiler window |
| `eps` | length scale |

## Details

Computes the sample correlation integral on the provided time series for the specified length scale, and considering a time window `t` (see references). It uses a naif algorithm: simply returns the fraction of points pairs nearer than `eps`. Normally, you would use `d2`, which takes roughly the same time, but computes the correlation sum for multiple length scales and embedding dimensions at once.

## Value

The sample correlation integral at `eps` length scale.

## Author(s)

Antonio, Fabio Di Narzo

### References

Hegger, R., Kantz, H., Schreiber, T., Practical implementation of nonlinear time series methods: The TISEAN package; CHAOS 9, 413-435 (1999)

### See Also

`d2`

---

## d2 — *Sample correlation integral (at multiple length scales)*

---

### Description

Computes the sample correlation integral over a grid of `neps` length scales starting from `eps.min`, and for multiple embedding dimensions

### Usage

```
d2(series, m, d, t, eps.min, neps=100)
```

### Arguments

| | |
|---|---|
| `series` | time series |
| `m` | max embedding dimension |
| `d` | time delay |
| `t` | Theiler window |
| `eps.min` | min length scale |
| `neps` | number of length scales to evaluate |

### Details

Computes the sample correlation integral over `neps` length scales starting from `eps.min`, for embedding dimension 1,...,m , considering a `t` time window (see references). The slope of the linear segment in the log-log plot gives an estimate of the correlation dimension (see the example).

### Value

Matrix. Column 1: length scales. Column i=2, ..., m+1: sample correlation integral for embedding dimension i-1.

### Author(s)

Antonio, Fabio Di Narzo

### References

Hegger, R., Kantz, H., Schreiber, T., Practical implementation of nonlinear time series methods: The TISEAN package; CHAOS 9, 413-435 (1999)

### Examples

```
d2(lorenz.ts, m=6, d=2, t=4, eps.min=2)
```

---

## duffing.syst *Duffing oscillator*

---

### Description

Duffing oscillator system, to be used with sim.cont

### Details

To be used with sim.cont

### Author(s)

Antonio, Fabio Di Narzo

---

## embedd *Embedding of a time series*

---

### Description

Embedding of a time series with provided time delay and embedding dimension parameters.

### Usage

```
embedd(x, m, d, lags)
```

### Arguments

| | |
|---|---|
| x | time series |
| m | embedding dimension (if lags missed) |
| d | time delay (if lags missed) |
| lags | vector of lags (if m and d are missed) |

### Details

Embedding of a time series with provided delay and dimension parameters.

## Value

Matrix with columns corresponding to lagged time series.

## Author(s)

Antonio, Fabio Di Narzo. Multivariate time series patch by Jonathan Shore.

## Examples

```
library(scatterplot3d)
x <- window(rossler.ts, start=90)
xyz <- embedd(x, m=3, d=8)
scatterplot3d(xyz, type="l")

## embedding multivariate time series
series <- cbind(seq(1,50),seq(101,150))
head(embedd(series, m=6, d=1))
```

---

`false.nearest` *Method of false nearest neighbours*

---

## Description

Method of false nearest neghbours to help deciding the optimal embedding dimension

## Usage

```
false.nearest(series, m, d, t, rt=10, eps=sd(series)/10)
```

## Arguments

| | |
|---|---|
| `series` | time series |
| `m` | maximum embedding dimension |
| `d` | delay parameter |
| `t` | Theiler window |
| `rt` | escape factor |
| `eps` | neighborhood diameter |

## Details

Method of false nearest neighbours to help deciding the optimal embedding dimension.

## Value

Fraction of false neighbors (first row) and total number of neighbors (second row) for each specified embedding dimension (columns)

### Author(s)

Antonio, Fabio Di Narzo

### References

Hegger, R., Kantz, H., Schreiber, T., Practical implementation of nonlinear time series methods: The TISEAN package; CHAOS 9, 413-435 (1999)

Kennel M. B., Brown R. and Abarbanel H. D. I., Determining embedding dimension for phase-space reconstruction using a geometrical construction, Phys. Rev. A, Volume 45, 3403 (1992).

### Examples

```
(fn.out <- false.nearest(rossler.ts, m=6, d=8, t=180, eps=1, rt=3))
plot(fn.out)
```

---

`lorenz.syst` *Lorenz system*

---

### Description

Lorenz system, to be used with `sim.cont`

### Details

To be used with `sim.cont`

### Author(s)

Antonio, Fabio Di Narzo

---

`lorenz.ts` *Lorenz simulated time series, without noise*

---

### Description

Lorenz simulated time series, without noise. Of each state of the system, we observe the euclidean norm.

### Details

Lorenz simulated time series, without noise, obtained with the call: `lorenz.ts <- sim.cont(lorenz.syst, 0, 100, 0.05`

### Author(s)

Antonio, Fabio Di Narzo

Lyapunov exponent — *Tools to evaluate the maximal Lyapunov exponent of a dynamic system*

## Description

Tools to evaluate the maximal Lyapunov exponent of a dynamic system from a univariate time series

## Usage

```
lyap_k(series, m, d, t, k=1, ref, s, eps)
lyap(dsts, start, end)
```

## Arguments

| | |
|---|---|
| series | time series |
| m | embedding dimension |
| d | time delay |
| k | number of considered neighbours |
| eps | radius where to find nearest neighbours |
| s | iterations along which follow the neighbours of each point |
| ref | number of points to take into account |
| t | Theiler window |
| dsts | Should be the output of a call to `lyap_k` (see the example) |
| start | Starting time of the linear bite of `dsts` |
| end | Ending time of the linear bite of `dsts` |

## Details

The function `lyap_k` estimates the largest Lyapunov exponent of a given scalar time series using the algorithm of Kantz.

The function `lyap` computes the regression coefficients of a user specified segment of the sequence given as input.

## Value

`lyap_k` gives the logarithm of the stretching factor in time.

`lyap` gives the regression coefficients of the specified input sequence.

## Author(s)

Antonio, Fabio Di Narzo

## References

Hegger, R., Kantz, H., Schreiber, T., Practical implementation of nonlinear time series methods: The TISEAN package; CHAOS 9, 413-435 (1999)

M. T. Rosenstein, J. J. Collins, C. J. De Luca, A practical method for calculating largest Lyapunov exponents from small data sets, Physica D 65, 117 (1993)

## See Also

`mutual`, `false.nearest` for the choice of optimal embedding parameters. `embedd` to perform embedding.

## Examples

```
output <-lyap_k(lorenz.ts, m=3, d=2, s=200, t=40, ref=1700, k=2, eps=4)
plot(output)
lyap(output, 0.73, 2.47)
```

---

`mutual` *Average Mutual Information*

---

## Description

Estimates the average mutual information index (ami) of a given time series for a specified number of lags

## Usage

```
mutual(series, partitions = 16, lag.max = 20, plot=TRUE, ...)
```

## Arguments

| | |
|---|---|
| `series` | time series |
| `partitions` | number of bins |
| `lag.max` | largest lag |
| `plot` | logical. If 'TRUE' (the default) the ami is plotted |
| `...` | further arguments to be passed to the plot method |

## Details

Estimates the mutual information index for a specified number of lags. The joint probability distribution function is estimated with a simple bi-dimensional density histogram.

## Value

An object of class "ami", which is a vector containing the estimated mutual information index for each lag between 0 and `lag.max`.

## Author(s)

Antonio, Fabio Di Narzo

## References

Hegger, R., Kantz, H., Schreiber, T., Practical implementation of nonlinear time series methods: The TISEAN package; CHAOS 9, 413-435 (1999)

## Examples

```
mutual(lorenz.ts)
```

---

`plot.ami` *Plotting average mutual information index*

---

## Description

Plotting method for objects inheriting from class '"ami"'.

## Usage

```
 ## S3 method for class 'ami'
plot(x, main = NULL, ...)
```

## Arguments

| | |
|---|---|
| `x` | '"ami"' object |
| `main, ...` | additional graphical arguments |

## Details

Plots the ami for each lag in `x`.

## Author(s)

Antonio, Fabio Di Narzo

## See Also

`mutual`

## plot.d2 *Plotting sample correlation integrals*

### Description

Plotting method for objects inheriting from class '"d2"'.

### Usage

```
## S3 method for class 'd2'
plot(x, ...)
```

### Arguments

| | |
|---|---|
| x | '"d2"' object |
| ... | additional graphical arguments |

### Details

Plots the sample correlation integrals in x in log-log scale, as a line for each considered embedding dimension.

### Author(s)

Antonio, Fabio Di Narzo

### See Also

d2

## plot.false.nearest *Plotting false nearest neighbours results*

### Description

Plotting method for objects inheriting from class '"false.nearest"'.

### Usage

```
## S3 method for class 'false.nearest'
plot(x, ...)
```

### Arguments

| | |
|---|---|
| x | '"false.nearest"' object |
| ... | additional graphical arguments |

### Details

Plots the results of `false.nearest`.

### Author(s)

Antonio, Fabio Di Narzo

### See Also

`false.nearest`

---

## print.d2 *Printing sample correlation integrals*

---

### Description

Printing method for objects inheriting from class '"d2"'.

### Usage

```
## S3 method for class 'd2'
print(x, ...)
```

### Arguments

| | |
|---|---|
| `x` | '"d2"' object |
| `...` | additional arguments to 'print' |

### Details

Simply calls `plot.d2`.

### Author(s)

Antonio, Fabio Di Narzo

### See Also

`plot.d2`, `d2`

## print.false.nearest — *Printing false nearest neighbours results*

### Description

Printing method for objects inheriting from class '"false.nearest"'.

### Usage

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

### Arguments

| | |
|---|---|
| `x` | '"false.nearest"' object |
| `...` | additional arguments to 'print' |

### Details

Prints the table of results of `false.nearest`.

### Author(s)

Antonio, Fabio Di Narzo

### See Also

`plot.false.nearest`, `false.nearest`

## recurr — *Recurrence plot*

### Description

Recurrence plot

### Usage

```
recurr(series, m, d, start.time=start(series), end.time=end(series), ...)
```

## Arguments

| | |
|---|---|
| `series` | time series |
| `m` | embedding dimension |
| `d` | time delay |
| `start.time` | starting time window (in time units) |
| `end.time` | ending time window (in time units) |
| `...` | further parameters to be passed to `filled.contour` |

## Details

Produces the recurrence plot, as proposed by Eckmann et al. (1987). White is maximum distance, black is minimum.

## warning

Be awared that number of distances to store goes as `n^2`, where `n = length(window(series, start=start.time, end=en`

## Author(s)

Antonio, Fabio Di Narzo

## References

Eckmann J.P., Oliffson Kamphorst S. and Ruelle D., Recurrence plots of dynamical systems, Europhys. Lett., volume 4, 973 (1987)

## Examples

```
recurr(lorenz.ts, m=3, d=2, start.time=15, end.time=20)
```

---

`rossler.syst` *Roessler system of equations*

---

## Description

Roessler system of equations

## Details

To be used with `sim.cont`.

## Author(s)

Antonio, Fabio Di Narzo

`rossler.ts` *Roessler simulated time series, without noise*

## Description

Roessler simulated time series, without noise. Of each state of the system, we observe the first component.

## Details

Roessler simulated time series, without noise, obtained with the call:

```
rossler.ts <- sim.cont(rossler.syst, start=0, end=650, dt=0.1, start.x=c(0,0,0), parms=c(0.15, 0.2, 1
```

## Author(s)

Antonio, Fabio Di Narzo

`sim.cont` *Simulates a continuous dynamic system*

## Description

Simulates a dynamic system of provided ODEs

## Usage

```
sim.cont(syst, start.time, end.time, dt, start.x, parms=NULL, obs.fun=function(x) x[1])
```

## Arguments

| | |
|---|---|
| `syst` | ODE system |
| `start.time` | starting time |
| `end.time` | ending time |
| `dt` | time between observations |
| `start.x` | initial conditions |
| `parms` | parameters for the system |
| `obs.fun` | observed function of the state |

## Details

Simulates a dynamic system of provided ODEs. Uses `lsoda` in `odesolve` for numerical integration of the system.

### Value

The time series of the observed function of the system's state

### Author(s)

Antonio, Fabio Di Narzo

### See Also

`lorenz.syst`, `rossler.syst`, `duffing.syst`

### Examples

```
rossler.ts <- sim.cont(rossler.syst, start=0, end=650, dt=0.1,
                       start.x=c(0,0,0), parms=c(0.15, 0.2, 10))
```

---

## `stplot` *Space-time separation plot*

---

### Description

Space-time separation plot

### Usage

```
stplot(series, m, d, idt=1, mdt)
```

### Arguments

| | |
|---|---|
| `series` | time series |
| `m` | embedding dimension |
| `d` | time delay |
| `idt` | observation steps in each iteration |
| `mdt` | number of iterations |

### Details

Produces the space-time separation plot, as introduced by Provenzale et al. (1992), which can be used to decide the Theiler time window `t`, which is required in many other algorithms in this package.

It plots the probability that two points in the reconstructed phase-space have distance smaller than epsilon in function of epsilon and of the time t between the points, as iso-lines at levels 10%, 20%, . . . , 100%.

### Value

lines of costant probability at 10%, 20%, . . . , 100%.

## Author(s)

Antonio, Fabio Di Narzo

## References

Kantz H., Schreiber T., Nonlinear time series analysis. Cambridge University Press, (1997)

Provenzale A., Smith L. A., Vio R. and Murante G., Distiguishing between low-dimensional dynamics and randomness in measured time series. Physica D., volume 58, 31 (1992)

## See Also

`false.nearest`, `d2`, `lyap_k`

## Examples

```
stplot(rossler.ts, m=3, d=8, idt=1, mdt=250)
```

# Index