Package 'NVAR'

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Title Nonlinear Vector Autoregression Models

Version 0.1.0

Description Estimate nonlinear vector autoregression models (also known as the next generation reservoir computing) for nonlinear dynamic systems. The algorithm was described by Gauthier et al. (2021) <doi:10.1038/s41467-021-25801-2>.

License GPL (>= 3)

Encoding UTF-8

RoxygenNote 7.2.3

Imports dplyr, magrittr, purrr, rlang, stats, tibble, tidyr

Suggests ggplot2, nonlinearTseries, testthat (>= 3.0.0)

Config/testthat/edition 3

URL https://github.com/Sciurus365/NVAR

BugReports https://github.com/Sciurus365/NVAR/issues

NeedsCompilation no

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R topics documented:

NVAR *Fit a nonlinear vector autoregression model*

Description

Described by Gauthier et al. (2021), also known as the "next generation reservoir computing" (NG-RC).

Usage

```
NVAR(data, vars, s, k, p, constant = TRUE, alpha = 0.05)
```

Arguments

data	A tibble, data.frame, or matrix that represents a time series of vectors, with each row as a time step.
vars	A character vector of the variable names used in the model.
s	The number of time steps skipped between each two used time steps.
k	The number of time steps used for constructing features.
p	The order of polynomial feature vector.
constant	Whether there should be a constant value (1) in the feature set? Default is TRUE.
alpha	The α value for ridge regression. Default is 0.05.

Details

The feature vector is as follows (from the reference):

$$\mathbb{O}_{\text{total}} = \mathbb{O}_{\text{lin}} \oplus \mathbb{O}^{(p)}_{\text{nonlinear}}$$

$$\mathbb{O}_{\text{lin},i} = \mathbf{X}_i \oplus \mathbf{X}_{i-s} \oplus \mathbf{X}_{i-2s} \oplus \ldots \oplus \mathbf{X}_{i-(k-1)s}$$

$$\mathbb{O}^{(p)}_{\text{nonlinear}} = \mathbb{O}_{\text{lin}} \lceil\otimes\rceil \mathbb{O}_{\text{lin}} \lceil\otimes\rceil \ldots \lceil\otimes\rceil \mathbb{O}_{\text{lin}}$$

The feature vector $\mathbb{O}_{\text{total}}$ is then used as input for a ridge regression with alpha.

Value

An NVAR object that contains data, data_td (a tidy form of tibble that contains the training data), W_out (the fitted coefficients), and parameters.

References

Gauthier, D. J., Bollt, E., Griffith, A., & Barbosa, W. A. S. (2021). Next generation reservoir computing. Nature Communications, 12(1), 5564. https://doi.org/10.1038/s41467-021-25801-2

See Also

sim_NVAR() for simulating the NVAR model.

Examples

```
# generate test data from the Lorenz system
testdata <- nonlinearTseries::lorenz()
testdata <- tibble::as_tibble(testdata)
# fit an NVAR model for the Lorenz system
t1 <- NVAR(data = testdata, vars = c("x", "y", "z"), s = 2, k = 2, p = 2, alpha = 1e-3)
# simulate the NVAR model
t1_sim <- sim_NVAR(t1, length = 5000)
# (also see README for the plots of the results and the comparison with the true model)
```

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sim_NVAR *Time series simulation with an NVAR model*

Description

Time series simulation with an NVAR model

Usage

```
sim_NVAR(
  model,
  init = NULL,
  length = 1000,
  noise = 0,
  upper_lim = Inf,
  lower_lim = -Inf
)
```

Arguments

model	An NVAR model, fitted by NVAR().
init	A tibble, data.frame, or matrix that specify the initial values for a simulation. Should contain the variables used to fit the model and be at least $s*(k-1)$ long. NULL by default, in which case the data used for fitting the model will be used for simulation.
length	How many time steps should be simulated? 1e3 by default.
noise	A number indicating the standard deviation of the Gaussian noise added to each time step. 0 by default (no noise).

`upper_lim, lower_lim`
: The upper and lower limit for the simulation. Once the simulated value is out of the limits, it will be taken back to avoid instability of the simulation. Both should either be a single number or a numeric vector with the same length as the number of variables in the model. `Inf` and `-Inf` by default, which means no limits.

Value

A `tibble` with the simulated time series.

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