Package ‘sindyr’

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Type Package
Title Sparse Identification of Nonlinear Dynamics
Version 0.2.1
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Description This implements the Brunton et al (2016; PNAS <doi:10.1073/pnas.1517384113>) sparse identification algorithm for finding ordinary differential equations for a measured system from raw data (SINDy). The package includes a set of additional tools for working with raw data, with an emphasis on cognitive science applications (Dale and Bhat, in press <doi:10.1016/j.cogsys.2018.06.020>).
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R topics documented:

sindyr-package .................................................. 2
features ......................................................... 3
finite_difference ................................................. 4
finite_differences ................................................ 4
sindy .......................................................... 5
windowed_sindy .................................................. 6

Index 7
**Description**

This implements the Brunton et al (2016; PNAS, doi: 10.1073/pnas.1517384113) sparse identification algorithm for finding ordinary differential equations for a measured system from raw data (SINDy). The package includes a set of additional tools for working with raw data, with an emphasis on cognitive science applications (Dale and Bhat, in press, doi: 10.1016/j.cogsys.2018.06.020).

**Details**

- **Package**: sindyr
- **Type**: Package
- **Version**: 0.2.1
- **Date**: 2018-09-10
- **License**: GPL >= 2

sindy: Main function to infer coefficient matrix for set of ODEs.

windowed_sindy: Sliding window function to obtain SINDy results across segments of a time series.

features: Function for generation feature space from measured variables.

finite_differences: Numerical differentiation over multiple columns.

sindy: Main function to infer coefficient matrix for set of ODEs.

windowed_sindy: Sliding window function to obtain SINDy results across segments of a time series.

features: Function for generation feature space from measured variables.

finite_differences: Numerical differentiation over multiple columns.

finite_difference: Numerical differential of a vector.

**Author(s)**

Rick Dale and Harish S. Bhat

**References**


For further examples and links to other materials see: https://github.com/racdale/sindyr
Examples

```r
# example to reconstruct of
# the Lorenz system

library(sindyr)

set.seed(666)
dt = .001
numsteps = 10000; dt = dt; sigma = 10; r = 28; b = 2.6;
xs = data.frame(lorenzattractor(numsteps, dt, sigma, r, b, plots=FALSE))
colnames(xs) = list('x', 'y', 'z')
xs = xs[2000:nrow(xs),] # cut out initialization

points3D(xs$x, xs$y, xs$z, type='l', col='black')
Theta = features(xs, 3) # grid of features
par(mfrow=c(7,3), oma = c(2,0,0,0) + 0.1, mar = c(1,1,1,1) + 0.1)
for (i in 2:ncol(Theta)) {
  plot(Theta[,i], xlab='t', main=gsub(':', '', colnames(Theta)[i]), type='l', xaxt='n', yaxt='n')
}
sindy.obj = sindy(xs=xs, dt=dt, lambda=.5) # let's reconstruct
sindy.obj$B # Lorenz equations
```

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**features**

*Build a matrix of features for SINDy*

**Description**

Takes a raw matrix of data and converts into polynomial features

**Arguments**

- `x` Raw data to be converted into features
- `polyorder` Order of polynomials (including k-th self products)
- `intercept` Include column of 1s in features to represent intercept (default = TRUE)

**Details**

Expands raw data into a set of polynomial features.

**Value**

Returns a new matrix of data with features from raw data

**Author(s)**

Rick Dale and Harish S. Bhat
finite_difference  
*Estimate derivative of variable with finite differences*

**Description**
Estimates first-order derivatives of a vector

**Arguments**
- *x*  
  Raw data to be differentiated
- *s*  
  Sample rate of data to return derivatives using raw time

**Details**
Uses simplest version of finite-difference method (window size 2) to numerically estimate derivative of a time series.

**Value**
Returns first-order numerical derivatives estimated from data.

**Author(s)**
Rick Dale and Harish S. Bhat

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finite_differences  
*Estimate derivatives of multiple variables with finite differences*

**Description**
Estimates first-order derivatives of column vectors of a matrix

**Arguments**
- *xs*  
  Raw data to be differentiated (matrix)
- *s*  
  Sample rate of data to return derivatives using raw time

**Details**
Uses simplest version of finite-difference method (window size 2) to numerically estimate derivative of multiple columnar time series.

**Value**
Returns first-order numerical derivatives estimated from data.
Description

Estimates coefficients for set of ordinary differential equations governing system variables.

Arguments

- **xs**: Matrix of raw data
- **dx**: Matrix of main system variable derivatives; if NULL, it estimates with finite differences from xs
- **dt**: Sample interval, if data continuously sampled; default = 1
- **Theta**: Matrix of features; if not supplied, assumes polynomial features of order 3
- **lambda**: Threshold to use for iterated least squares sparsification (Brunton et al.)
- **b.expected**: The function will compute a goodness of fit if supplied with an expected coefficient matrix B; default = NULL
- **verbose**: Verbose mode outputs Theta and dx values in their entirety; default = FALSE
- **fit.its**: Number of iterations to conduct the least-square threshold sparsification; default = 10
- **plot.eq.graph**: When set to TRUE, prints an igraph plot of variables as a graph structure; default = FALSE

Details

Uses the "left-division" approach of Brunton et al. (2016), and implements least-squares sparsification, and outputs coefficients after iterations stabilize.

Value

Returns a matrix B of coefficients specifying the relationship between dx and Theta

Author(s)

Rick Dale and Harish S. Bhat

References


windowed_sindy

Run SINDy over time windows

Description

Run SINDy on raw data with a sliding window approach

Arguments

- **xs**: Matrix of raw data
- **dx**: Matrix of main system variable derivatives; if NULL, it estimates with finite differences from xs
- **dt**: Sample interval, if data continuously sampled; default = 1
- **theta**: Matrix of features; if not supplied, assumes polynomial features of order 3
- **lambda**: Threshold to use for iterated least squares sparsification (Brunton et al.)
- **fit.its**: Number of iterations to conduct the least-square threshold sparsification; default = 10
- **B.expected**: The function will compute a goodness of fit if supplied with an expected coefficient matrix B; default = NULL
- **window.size**: Size of window to segment raw data as separate time series; defaults to deciles
- **window.shift**: Step sizes across windows, permitting overlap; defaults to deciles

Details

A convenience function for extracting a list of coefficients on segments of a time series. This facilitates using SINDy output as source of descriptive measures of dynamics.

Value

It returns a list of coefficients Bs containing B coefficients at each window

Author(s)

Rick Dale and Harish S. Bhat

References

Index

*Topic misc
  features, 3
  finite_difference, 4
  finite_differences, 4
  sindy, 5
  windowed_sindy, 6

*Topic package
  sindyr-package, 2

features, 3
finite_difference, 4
finite_differences, 4

sindy, 5
sindyr-package, 2

windowed_sindy, 6