Package ‘feature’

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Title Feature significance for multivariate kernel density estimation

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Description Feature significance for multivariate kernel density estimation

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feature-package

Description

Package for feature significance for multivariate kernel density estimation.

Details

The feature package contains functions to display and compute kernel density estimates, significant gradient and significant curvature regions. Significant gradient and/or curvature regions often correspond to significant features (e.g. local modes).

There are two main functions in this package. featureSignifGUI is the interactive function where the user can select bandwidths from a pre-defined range. This mode is useful for initial exploratory data analysis. featureSignif is the non-interactive function. This is useful when the user has a more definite idea of suitable values for the bandwidths. For a more detailed example for 1-d and 2-d data, see vignette("feature").

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See Also

ks, sm, KernSmooth

earthquake

Mt St Helens earthquake data

Description

This data set is a reduced version of the full data set in Scott (1992). It contains the first three variables.

Usage

data(earthquake)

Format

A matrix with 3 columns and 510 rows. Each row corresponds to the measurements of an earthquake beneath the Mt St Helens volcano. The first column is the longitude (in degrees, where a negative number indicates west of the International Date Line), the second column is the latitude (in degrees, where a positive number indicates north of the Equator) and the third column is the depth (in km, where a negative number indicates below the Earth’s surface).
featureSignif

Description

Identify significant features of kernel density estimates of 1- to 4-dimensional data.

Usage

featureSignif(x, bw, gridsize, scaleData=FALSE, addSignifGrad=TRUE, addSignifCurv=TRUE, signifLevel=0.05)

Arguments

x        data matrix
bw       vector of bandwidth(s)
gridsize vector of estimation grid sizes
scaleData flag for scaling the data i.e. transforming to unit variance for each dimension.
addSignifGrad flag for computing significant gradient regions
addSignifCurv flag for computing significant curvature regions
signifLevel significance level

Details

Feature significance is based on significance testing of the gradient (first derivative) and curvature (second derivative) of a kernel density estimate. This was developed for 1-d data by Chaudhuri & Marron (1995), for 2-d data by Godtliebsen, Marron & Chaudhuri (1999), and for 3-d and 4-d data by Duong, Cowling, Koch & Wand (2007).

The test statistic for gradient testing is at a point \( x \) is

\[
W(x) = \| \hat{\nabla} f(x; H) \|^2
\]

where \( \hat{\nabla} f(x; H) \) is kernel estimate of the gradient of \( f(x) \) with bandwidth \( H \), and \( \| \cdot \| \) is the Euclidean norm. \( W(x) \) is approximately chi-squared distributed with \( d \) degrees of freedom where \( d \) is the dimension of the data.

The analogous test statistic for curvature is

\[
W^{(2)}(x) = \| \text{vech} \hat{\nabla}^{(2)} f(x; H) \|^2
\]

where \( \hat{\nabla}^{(2)} f(x; H) \) is the kernel estimate of the curvature of \( f(x) \), and \( \text{vech} \) is the vector-half operator. \( W^{(2)}(x) \) is approximately chi-squared distributed with \( d(d+1)/2 \) degrees of freedom.

Since this is a situation with many dependent hypothesis tests, we use a multiple comparison or simultaneous test to control the overall level of significance. We use a Hochberg-type procedure. See Hochberg (1988) and Duong, Cowling, Koch & Wand (2007).
featureSignif

Value

Returns an object of class \texttt{fs} which is a list with the following fields:

- \texttt{x} \hspace{1em} data matrix
- \texttt{names} \hspace{1em} name labels used for plotting
- \texttt{bw} \hspace{1em} vector of bandwidths
- \texttt{fhat} \hspace{1em} kernel density estimate on a grid
- \texttt{grad} \hspace{1em} logical grid for significant gradient
- \texttt{curv} \hspace{1em} logical grid for significant curvature
- \texttt{gradData} \hspace{1em} logical vector for significant gradient data points
- \texttt{gradDataPoints} \hspace{1em} significant gradient data points
- \texttt{curvData} \hspace{1em} logical vector for significant curvature data points
- \texttt{curvDataPoints} \hspace{1em} significant curvature data points

References


See Also

\texttt{featureSignifGUI, plot.fs}

Examples

```r
## Univariate example
data(earthquake)
eq3 <- -log10(earthquake[,3])
fs <- featureSignif(eq3, bw=0.1)
plot(fs, addSignifGradRegion=TRUE)

## Bivariate example
library(MASS)
data(geyser)
fs <- featureSignif(geyser)
plot(fs, addSignifCurvRegion=TRUE)

## Trivariate example
data(earthquake)
```
Description

GUI for feature significance for kernel density estimation.

Usage

featureSignifGUI(x, scaleData=FALSE)

Arguments

x       data matrix
scaleData  flag for scaling the data to the unit interval in each dimension

Details

In the first column are the sliders for selecting the bandwidths (one for each dimension). Move
the slider buttons to change the value of the bandwidths. The text field is for the grid size which
specifies the number of points in each dimension of the kernel estimation binning grid. Press the
‘Compute significant features’ button to begin the computation. This creates a plot of the kernel
density estimate (KDE) from the data with the specified bandwidths by calling featureSignif.
Once this complete, a pop-up window will appear.

In the second column are the axis limits and labels. The last text field is for the (maximum) number
of data points used in the display. Press the ‘Reset plot (except KDE)’ button to clear the plot of all
added features except for the KDE itself.

In the third column are 5 buttons which can be used to add to the KDE plot such as the data points,
significant gradient points-regions and significant curvature points-regions. For 1-d data, the button
in the third column is ‘Compute SiZer map’. Press this button to compute a gradient SiZer plot
using the SiZer function. Once this complete, a pop-up window will appear. For 2- and 3-d data,
the button in the third column is ‘Reset plot’. This will clear the plot of all features as well as the
KDE. This is useful for showing only the significant features when the KDE may interfere with
their display.

For 3-d data, there is an extra fourth column of options: these are sliders for the transparency values
for the features. Move the slider button along to the desired value (between 0 and 1) and then press
the ‘Add ...’ button to the left. Repeatedly pressing the ‘Add ...’ button will cause the transparency
of the features to decrease. In this case, press the one of the ‘Reset plot’ buttons to clear the plot
window, and replot the significant feature with the desired transparency.

earthquake[,3] <- -log10(-earthquake[,3])
fs <- featureSignif(earthquake, scaleData=TRUE, bw=c(0.06, 0.06, 0.05))
plot(fs, addKDE=TRUE)
plot(fs, addKDE=FALSE, addSignifCurvRegion=TRUE)
Examples

```r
## Not run:
library(MASS)
data(geyser)
duration <- geyser$duration
featureSignifGUI(duration)  ## univariate example
featureSignifGUI(geyser)    ## bivariate example

data(earthquake)           ## trivariate example
earthquake$depth <- -log10(-earthquake$depth)
featureSignifGUI(earthquake, scaleData=TRUE)
## End(Not run)
```

plot.fs  

Feature significance plot for 1- to 3-dimensional data

Description

Feature significance plot for 1- to 3-dimensional data.

Usage

## S3 method for class 'fs'
plot(x, ..., xlab, ylab, zlab, xlim, ylim, zlim,
     add=FALSE, addData=FALSE, scaleData=FALSE, addDataNum=1000,
     addKDE=TRUE, jitterRug=TRUE,
     addSignifGradRegion=FALSE, addSignifGradData=FALSE,
     addSignifCurvRegion=FALSE, addSignifCurvData=FALSE,
     addAxes3d=TRUE, densCol, dataCol="black", gradCol="green",
     curvCol="blue", axisCol="black", bgCol="white",
     dataAlpha=0.1, gradDataAlpha=0.3, gradRegionAlpha=0.2,
     curvDataAlpha=0.3, curvRegionAlpha=0.3)

Arguments

- `x`  
an object of class `fs` (output from `featureSignif` function)
- `xlim`, `ylim`, `zlim`  
x-, y-, z-axis limits
- `xlab`, `ylab`, `zlab`  
x-, y-, z-axis labels
- `scaleData`  
flag for scaling the data i.e. transforming to unit variance for each dimension
- `add`  
flag for adding to an existing plot
- `addData`  
flag for display of the data
- `addDataNum`  
maximum number of data points plotted in displays
- `addKDE`  
flag for display of kernel density estimates
jitterRug    flag for jittering of rug-plot for univariate data display

addSignifGradRegion, addSignifGradData
    flag for display of significant gradient regions/data points

addSignifCurvRegion, addSignifCurvData
    flag for display of significant curvature regions/data points

addAxes3d    flag for displaying axes in 3-d displays

densCol     colour of density estimate curve

dataCol     colour of data points

gradCol     colour of significant gradient regions/data points

curvCol     colour of significant curvature regions/data points

axisCol     colour of axes

bgCol       colour of background

dataAlpha   transparency of data points

gradRegionAlpha, gradDataAlpha
    transparency of significant gradient regions/data points

curvRegionAlpha, curvDataAlpha
    transparency of significant curvature regions/data points

...          other graphics parameters

Value

Plot of 1-d and 2-d kernel density estimates are sent to graphics window. Plot for 3-d is sent to RGL window.

See Also

featureSignif

Examples

library(MASS)
data(geyser)
fs <- featureSignif(geyser, bw=c(4.5, 0.37))
plot(fs, addKDE=FALSE, addData=TRUE)  ## data only
plot(fs, addKDE=TRUE)                ## KDE plot only
plot(fs, addSignifGradRegion=TRUE)
plot(fs, addKDE=FALSE, addSignifCurvRegion=TRUE)
plot(fs, addSignifCurvData=TRUE, curvCol="cyan")
SiZer, siCon

SiZer and SiCon plots for 1-dimensional data

Description

SiZer (Significant Zero crossings) and (Significant Convexity) plots for 1-dimensional data.

Usage

SiZer(x, bw, gridsize, scaleData=FALSE, signifLevel=0.05,
plotSiZer=TRUE, logbw=TRUE, xlim, xlab,
addLegend=TRUE, posLegend="bottomright")

SiCon(x, bw, gridsize, scaleData=FALSE, signifLevel=0.05,
plotSiCon=TRUE, logbw=TRUE, xlim, xlab,
addLegend=TRUE, posLegend="bottomright")

Arguments

x       data vector
bw      vector of range of bandwidths
gridsize number of x- and y-axis grid points
scaleData flag for scaling the data i.e. transforming to unit variance for each dimension.
signifLevel significance level
plotSiZer,plotSiCon flag for displaying SiZer/SiCon map
logbw   flag for displaying log bandwidths on y-axis
xlim    x-axis limits
xlab    x-axis label
addLegend flag for legend display
posLegend legend position

Details

The gradient SiZer and curvature SiCon maps of Chaudhuri & Marron (1999) are implemented. The horizontal axis is the data axis, the vertical axis are the bandwidths. The colour scheme for the SiZer map is red: negative gradient, blue: positive gradient, purple: zero gradient and grey: sparse regions. For the SiCon map, orange: negative curvature (concave), blue: positive curvature (convex), green: zero curvature and grey: sparse regions.

Value

SiZer plot sent to graphics window.
SiZer, siCon

References


See Also

`featureSignif`

Examples

```r
data(earthquake)
eq3 <- -log10(-earthquake[,3])
SiZer(eq3)
SiCon(eq3)
```
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