Package ‘DepthProc’

April 22, 2019

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Title   Statistical Depth Functions for Multivariate Analysis
Description Data depth concept offers a variety of powerful and user friendly tools for robust exploration and inference for multivariate data. The offered techniques may be successfully used in cases of lack of our knowledge on parametric models generating data due to their nature. The package consist of among others implementations of several data depth techniques involving multivariate quantile-quantile plots, multivariate scatter estimators, multivariate Wilcoxon tests and robust regressions.
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**Description**

Add fitted line to a plot. This is overloaded function for robust regression methods from package depthproc.

**Usage**

```r
## S4 method for signature 'RobReg'
abline(a = NULL, b = NULL, h = NULL, v = NULL,
        reg = NULL, coef = NULL, untf = FALSE, ...)
```

**Arguments**

- `a`: an object of class RobReg
- `b`: not used.
- `h`: not supported.
- `v`: not supported.
- `reg`: not supported.
- `coef`: not supported.
- `untf`: not supported.
- `...`: Arguments to be passed to methods, such as graphical parameters (see par).
as.matrix

as.matrix method for DepthCurveList.

Description
Create a matrix from DepthCurve and DepthCurveList.

Usage
as.matrix(x, ...)

## S4 method for signature 'DepthCurveList'
as.matrix(x)

Arguments

x
an object of class that inherits from DepthCurveList (ScaleCurveList or AsymmetryCurveList).

...
other arguments passed to standard as.matrix function.

asymmetryCurve

Asymmetry curve based on depths

Description
Produces an asymmetry curve estimated from given data.

Usage
asymmetryCurve(x, y = NULL, alpha = seq(0, 1, 0.01),
movingmedian = FALSE, name = "X", name_y = "Y",
depth_params = list(method = "Projection"))

Arguments

x
The data as a matrix or data frame. If it is a matrix or data frame, then each row
is viewed as one multivariate observation.

y
Additional matrix of multivariate data.

alpha
An ordered vector containing indices of central regions used for asymmetry curve
calculation.

movingmedian
Logical. For default FALSE only one depth median is used to compute asymmetry norm. If TRUE — for every central area, a new depth median will be used — this approach needs much more time.

name
Name of set X — used in plot legend
asymmetryCurve

name_y  Name of set Y — used in plot legend
depth_params  list of parameters for function depth (method, threads, ndir, la, lb, pdim, mean, cov, exact).
method  Character string which determines the depth function used. The method can be "Projection" (the default), "Mahalanobis", "Euclidean", "Tukey" or "LP". For details see depth.

Details

For sample depth function \( D(x, Z^n), x \in \mathbb{R}^d, d \geq 2, Z^n = \{z_1, ..., z_n\} \subset \mathbb{R}^d, D_\alpha(Z^n) \) denoting \( \alpha \) — central region, we can define the asymmetry curve \( AC(\alpha) = (\alpha, \|c^{-1}(\bar{z} - \text{med} D_\alpha(Z^n))\|) \subset R^2, \) for \( \alpha \in [0, 1] \) being nonparametric scale and asymmetry functional correspondingly, where \( c \) — denotes constant, \( \bar{z} \) — denotes mean vector, denotes multivariate median induced by depth function and \( vol \) — denotes a volume.

Asymmetry curve takes uses function convhulln from package geometry for computing a volume of convex hull containing central region.

Author(s)

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.

References


See Also

scaleCurve, depth

Examples

```
# EXAMPLE 1
library(sn)
x1 <- c(0, 0)
alpha <- c(2, -5)
Omega <- diag(2) * 5
n <- 500
X <- rmvnorm(n, xi, Omega) # normal distribution
```
```r
Y <- rmst(n = xi, Omega, alpha, nu = 1)
asymmetryCurve(X = Y, name = "NORM", name_y = "S_T(2, -5, 10)"
)

# EXAMPLE 2
data(under5.mort)
data(inf.mort)
data(maesles.imm)
data1990 <- cbind(under5.mort[, 1], inf.mort[, 1], maesles.imm[, 1])
data2011 <- cbind(under5.mort[, 22], inf.mort[, 22], maesles.imm[, 22])
as1990 <- asymmetryCurve(data1990, name = "scale curve 1990")
as2011 <- asymmetryCurve(data2011, name = "scale curve 2011")
figure <- getPlot(combineDepthCurves(as1990, as2011)) +
ggtitle("Scale curves")
figure```

---

### AsymmetryCurve-class

**AsymmetryCurve and AsymmetryCurveList**

#### Description

AsymmetryCurve is a class that stores results of asymmetryCurve function.

#### Details

The mechanism of creating plots with multiple curves is shown in DepthCurve-class (same mechanism is applied for ScaleCurve).

---

### BinnDepth2d-class

**BinnDepth2d**

#### Description

Class that stores result of function binningDepth2D(...)

#### Slots

freq Matrix with number of elements in certain bin.
mid_x Middle values on x-axis.
mid_y Middle values on y-axis.
breaks_x Boundaries of bins.
breaks_y Boundaries of bins.
input_data Binned data.
max_depth_x Point with maximum depth on x-axis.
max_depth_y Point with maximum depth on y-axis.
2d Binning

Description

A robust method of decreasing a sample size and therefore a complexity of a statistical procedure. The method may be used within a kernel density or a predictive distribution estimation.

Usage

`binningDepth2D(x, binmethod = "LocDepth", nbins = 8, k = 1, remove_borders = FALSE, depth_params = list(method = "LP"))`

Arguments

- `x`: bivariate matrix containing data. Each row is viewed as one two-dimensional observation.
- `binmethod`: A method for calculation center and dispersion measures. "LocDepth" uses location-scale depth, MAD uses median and MAD in each dimension.
- `nbins`: number of bins in each dimension
- `k`: responsible for tightness of bins.
- `remove_borders`: Logical, include or not marginal bins
- `depth_params`: other arguments passed to depthMedian

Details

Let us recall, that binning is a popular method of decreasing a sample size. To bin a window of \( n \) points \( W_{i,n} = \{X_{i-n+1}, ..., X_i\} \) to a grid \( X'_1, ..., X'_m \) we simply assign each sample point \( X_i \) to the nearest grid point \( X'_j \). When binning is completed, each grid point \( X'_j \) has an associated number \( c_i \), which is the sum of all the points that have been assigned to \( X'_j \). This procedure replaces the data \( W_{i,n} = \{X_{i-n+1}, ..., X_i\} \) with the smaller set \( W'_{j,m} = \{X'_{j-m+1}, ..., X'_j\} \). Although simple binning can speed up the computation, it is criticized for a lack of precise approximate control over the accuracy of the approximation. Robust binning however stresses properties of the majority of the data and decreases the computational complexity of the DSA at the same time.

For a 1D window \( W_{i,n} \), let \( Z_{i,n-k} \) denote a 2D window created basing on \( W_{i,n} \) and consisted of \( n-k \) pairs of observations and the \( k \) lagged observations \( Z_{i,n-k} = \{(X_{i-n-k}, X_{i-k+1})\}, 1 \leq i \leq n-k \). Robust 2D binning of the \( Z_{i,n-k} \) is a very useful technique in a context of robust estimation of the predictive distribution of a time series (see Kosiorowski:2013b).

Assume we analyze a data stream \( \{X_t\} \) using a moving window of a fixed length \( n \), i.e., \( W_{i,n} \) and the derivative window \( Z_{i,n-1} \). In a first step we calculate the weighted sample \( L^p \) depth for \( W_{i,n} \). Next we choose equally spaced grid of points \( l_1, ..., l_m \) in this way that \([l_1, l_m] \times [l_1, l_m]\) covers fraction of the \( \beta \) central points of \( Z_{i,n-1} \) w.r.t. the calculated \( L^p \) depth, i.e., it covers \( R^\beta(Z_{i,n-1}) \) for certain prefixed threshold \( \beta \in (0, 1) \). For both \( X_t \) and \( X_{t-1} \) we perform a simple binning using following bins: \((-\infty, l_1], (l_1, l_2], ..., (l_m, \infty)\). For robust binning we reject "border" classes and further use only midpoints and binned frequencies for classes \((l_1, l_2), (l_2, l_3), ..., (l_{m-1}, l_m)\).
Value

- freq: a matrix containing the binned frequencies
- mid_x: mid points for x
- mid_y: mid points for y
- breaks_x: breaks for x
- breaks_y: breaks for y
- input_data: max_depth_x and max_depth_y

Author(s)

Daniel Kosiorowski and Zygmunt Zawadzki from Cracow University of Economics.

References


See Also

depth

Examples

```r
# EXAMPLE 1
Sigma1 <- matrix(c(10, 3, 3, 2, 2)
X1 <- mvrnorm(n = 8500, mu = c(0, 0), Sigma1)
Sigma2 <- matrix(c(10, 0, 0, 2, 2)
X2 <- mvrnorm(n = 1500, mu = c(-10, 6), Sigma2)
BALLOT <- rbind(X1, X2)
train <- sample(1:10000, 500)
data <- BALLOT[train, ]
plot(data)
b1 <- binningDepth2D(data, remove_borders = FALSE, nbins = 12, k = 1)
b2 <- binningDepth2D(data, nbins = 12, k = 1, remove_borders = TRUE)
plot(b1)
plot(b2)

# EXAMPLE 2
data(under5.mort)
data(maesles.imm)
data2011 <- cbind(under5.mort[, 22], maesles.imm[, 22])
plot(binningDepth2D(data2011, nbins = 8, k = 0.5, remove_borders = TRUE))
```
**Description**

Adds plots

**Usage**

```r
combineDepthCurves(x, y, .list = NULL)

## S4 method for signature 'ANY,ANY,list'
combineDepthCurves(x, y, .list = NULL)

## S4 method for signature 'DepthCurveList,DepthCurve,ANY'
combineDepthCurves(x, y, .list = NULL)

## S4 method for signature 'DepthCurve,DepthCurveList,ANY'
combineDepthCurves(x, y, .list = NULL)

## S4 method for signature 'DepthCurve,DepthCurve,ANY'
combineDepthCurves(x, y, .list = NULL)
```

**Arguments**

- `x` object
- `y` object
- `.list` list of plots to combine.

**Details**

See `DepthCurve-class` for description.

---

**CovDepthWeighted-class**

*CovLP*

**Description**

This class, derived from the virtual class "CovRobust" accomodates weighted by $L^p$ depth multivariate location and scatter estimator.
Details
See CovLP for the function used to calculate weighted by $L^p$ depth covariance matrix.

CovLP CovLp

Description
Weighted by $L^p$ depth (outlyingness) multivariate location and scatter estimators.

Usage
CovLP(x, pdim = 2, la = 1, lb = 1)

Arguments
x The data as a matrix or data frame. If it is a matrix or data frame, then each row is viewed as one multivariate observation.
pdim The parameter of the weighted $L^p$ depth
la parameter of a simple weight function $w = ax + b$
lb parameter of a simple weight function $w = ax + b$

Details
Using depth function one can define a depth-weighted location and scatter estimators. In case of location estimator we have

$$L(F) = \int x w_1(D(x, F)) dF(x) / w_1(D(x, F)) dF(x)$$

Subsequently, a depth-weighted scatter estimator is defined as

$$S(F) = \int \frac{(x - L(F))(x - L(F))^T w_2(D(x, F)) dF(x)}{w_2(D(x, F)) dF(x)}$$

where $w_2(\cdot)$ is a suitable weight function that can be different from $w_1(\cdot)$.

The DepthProc package offers these estimators for weighted $L^p$ depth. Note that $L(\cdot)$ and $S(\cdot)$ include multivariate versions of trimmed means and covariance matrices. Their sample counterparts take the form

$$TWD(X^n) = \sum_{i=1}^{n} d_i X_i / \sum_{i=1}^{n} d_i,$$

$$DIS(X^n) = \sum_{i=1}^{n} d_i (X_i - TWD(X^n)) (X_i - TWD(X^n))^T / \sum_{i=1}^{n} d_i$$

where $d_i$ are sample depth weights, $w_1(x) = w_2(x) = x$. 
Value

loc: Robust Estimate of Location:
cov: Robust Estimate of Covariance:
Returns depth weighted covariance matrix.

Author(s)

Daniel Kosiorowski and Zygmunt Zawadzki from Cracow University of Economics.

See Also

depthContour and depthPersp for depth graphics.

Examples

```r
# EXAMPLE 1
x <- mvrnorm(n = 100, mu = c(0, 0), Sigma = 3 * diag(2))
cov_x <- CovLP(x, 2, 1, 1)

# EXAMPLE 2
data(under5.mort, inf.mort, maesles.imm)
data1990 <- na.omit(cbind(under5.mort[, 1], inf.mort[, 1], maesles.imm[, 1]))
CovLP(data1990)
```

---

cracow.airpollution  Air pollution with PM10 in Cracow within day and night in December 2016

Description

Air pollution with PM10 in Cracow within day and night in December 2016

Usage

data("cracow.airpollution")

Format

data frame containing 744 rows.

References

ddmvnorm

Normal depth versus depth plot

Description

Produces a normal DD plot of a multivariate dataset.

Usage

ddMvnorm(x, size = nrow(x), robust = FALSE, alpha = 0.05, title = "ddMvnorm", depth_params = list())

Arguments

- **x**: The data sample for DD plot.
- **size**: size of theoretical set
- **robust**: Logical. Default FALSE. If TRUE, robust measures are used to specify the parameters of theoretical distribution.
- **alpha**: cutoff point for robust measure of covariance.
- **title**: title of a plot.
- **depth_params**: list of parameters for function depth (method, threads, ndir, la, lb, pdim, mean, cov, exact).

Details

In the first step the location and scale of x are estimated and theoretical sample from normal distribution with those parameters is generated. The plot presents the depth of empirical points with respect to dataset x and with respect to the theoretical sample.

Value

Returns the normal depth versus depth plot of multivariate dataset x.

Author(s)

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.

References


See Also

`ddPlot` to generate ddPlot to compare to datasets or to compare a dataset with other distributions.

Examples

```r
# EXAMPLE 1
norm <- mvrnorm(1000, c(0, 0, 0), diag(3))
con <- mvrnorm(100, c(1, 2, 5), 3 * diag(3))
sample <- rbind(norm, con)
ddMvnorm(sample, robust = TRUE)

# EXAMPLE 2
data(under5.mort, inf.mort, maesles.imm)
data1990 <- na.omit(cbind(under5.mort[, 1], inf.mort[, 1], maesles.imm[, 1]))
ddMvnorm(data1990, robust = FALSE)
```

---

**ddPlot**  
*Depth versus depth plot*

Description

Produces a DD plot which allows to compare two multivariate datasets or to compare a subject dataset with theoretical distribution.

Usage

```r
ddPlot(x, y, scale = FALSE, location = FALSE, name = "x", name_y = "y", title = "Depth vs. depth plot", depth_params = list())
```

Arguments

- **x**
  - The first or only data sample for ddPlot.
- **y**
  - The second data sample. x and y must be of the same space.
- **scale**
  - logical. determines whether the dispersion is to be aligned.
- **location**
  - determines whether the location is to be aligned to 0 vector with depth median.
- **name**
  - name for data set x. It will be passed to drawing function.
- **name_y**
  - as above for y
- **title**
  - title of the plot.
- **depth_params**
  - list of parameters for function depth (method, threads, ndir, la, lb, pdim, mean, cov, exact).
Details

For two probability distributions $F$ and $G$, both in $R^d$, we can define depth vs. depth plot being very useful generalization of the one dimensional quantile-quantile plot:

$$DD(F, G) = \{(D(z, F), D(z, G)) , z \in R^d\}$$

Its sample counterpart calculated for two samples $X^n = \{X_1, ..., X_n\}$ from $F$, and $Y^m = \{Y_1, ..., Y_m\}$ from $G$ is defined as

$$DD(F_n, G_m) = \{(D(z, F_n), D(z, G_m)) , z \in \{X^n \cup Y^m\}\}$$

Author(s)

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.

References


Examples

library(sn)
library(mvtnorm)

# EXAMPLE 1: Location difference
standard <- mvrnorm(1000, c(0, 0), diag(2))
shift <- mvrnorm(1000, c(0.5, 0), diag(2))
ddPlot(x = standard, y = shift, title = "Difference in position")
ddPlot(x = standard, y = shift, location = TRUE, title = "Location aligned")

# EXAMPLE 2: Scale difference
standard <- mvrnorm(1000, c(0, 0), diag(2))
scale <- mvrnorm(1000, c(0, 0), 4 * diag(2))
ddPlot(x = standard, y = scale)
ddPlot(x = standard, y = scale, scale = TRUE)
**deepReg2d**

**Slots**

- `X` Object of class `Depth-class`.
- `Y` Object of class `Depth-class`.
- `title` title of a plot.

---

**deepReg2d**  
*Simple deepest regression method.*

**Description**

This function calculates deepest regression estimator for simple regression.

**Usage**

```
depReg2d(x, y)
```

**Arguments**

- `x` Independent variable.
- `y` Dependent variable.

**Details**

Function originates from an original algorithm proposed by Rousseeuw and Hubert. Let $Z^n = (x_1, y_1), ... , (x_n, y_n) \subset R^d$ denotes a sample considered from a following semiparametric model:  

$$y_l = a_0 + a_1 x_{1l} + ... + a_{(d-1)} x_{(d-1)l} + \varepsilon_l, l = 1, ..., n,$$

we calculate a depth of a fit $\alpha = (a_0, ..., a_{d-1})$ as 

$$RD(\alpha, Z^n) = u \neq 0 \min \{l : \frac{r(l)(\alpha)}{u^T x_l} < 0, l = 1, ..., n, \text{ where } r(\cdot) \text{ denotes the regression residual}, \alpha = (a_0, ..., a_{d-1}), u^T x_l \neq 0 \},$$

the deepest regression estimator $DR(\alpha, Z^n)$ is defined as 

$$DR(\alpha, Z^n) = \alpha \neq 0 \arg \max RD(\alpha, Z^n)$$

**Author(s)**

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.

**References**

Examples

```r
# EXAMPLE 1
data(pension)
plot(pension)
abline(
  lm(Reserves ~ Income, data = pension),
  lty = 3,
  lwd = 2) # lm
abline(
  deepReg2d(pension[, 1], pension[, 2]),
  lwd = 2) # deepreg2d

# EXAMPLE 2
data(under5.mort)
data(inf.mort)
data(maesles.imm)
data2011 <- na.omit(
  cbind(under5.mort[, 22], inf.mort[, 22],
        maesles.imm[, 22]))

x <- data2011[, 3]
y <- data2011[, 2]
plot(
  x, y,
  cex = 1.2,
  ylab = "infant mortality rate per 1000 live birth",
  xlab = "against masles immunized percentage",
  main = "Projection Depth Trimmed vs. LS regressions"
)
abline(lm(x ~ y), lwd = 2, col = "black") # lm
abline(
  deepReg2d (x, y),
  lwd = 2, col = "red"
) # trimmed reg
legend(
  "bottomleft",
  c("LS", "DeepReg"),
  fill = c("black", "red"),
  cex = 1.4,
  bty = "n"
)
```

---

**Description**

Class for robust regression methods from depthproc package
Slots

- coef: coefficients of fitted model
- depth: regression depth of the fitted values

---

**Description**

Calculate depth functions.

**Usage**

```
depth(u, X, method = "Projection", threads = -1, ...)
```

**Arguments**

- `u`: Numerical vector or matrix whose depth is to be calculated. Dimension has to be the same as that of the observations.
- `X`: The data as a matrix, data frame or list. If it is a matrix or data frame, then each row is viewed as one multivariate observation. If it is a list, all components must be numerical vectors of equal length (coordinates of observations).
- `method`: Character string which determines the depth function. Method can be "Projection" (the default), "Mahalanobis", "Euclidean" or "Tukey". For details see `depth`.
- `threads`: number of threads used in parallel computations. Default value -1 means that all possible cores will be used.
- `...`: parameters specific to method — see `depthEuclid`

**Details**

The Mahalanobis depth

\[ D_{MAH}(y, X^n) = \frac{1}{1 + (y - \bar{x})^T S^{-1} (y - \bar{x})}, \]

where \( S \) denotes the sample covariance matrix \( X^n \).

A symmetric projection depth \( D(x, X) \) of a point \( x \in \mathbb{R}^d, d \geq 1 \) is defined as

\[ D(x, X)_{PRO} = \left[ 1 + \sup_{||u||=1} \frac{|u^T x - Med(u^T X)|}{MAD(u^T X)} \right]^{-1}, \]

where \( Med \) denotes the univariate median, \( MAD(Z) = Med(|Z - Med(Z)|) \). Its sample version denoted by \( D(x, X^n) \) or \( D(x, X^n) \) is obtained by replacing \( F \) by its empirical counterpart \( F_n \) calculated from the sample \( X^n \).
Next interesting depth is the weighted $L^p$ depth. The weighted $L^p$ depth $D(x, F)$ of a point $x \in \mathbb{R}^d$, $d \geq 1$ generated by $d$ dimensional random vector $X$ with distribution $F$, is defined as $D(x, F) = \frac{1}{1 + \mathbb{E}w(\|x - X\|_p)}$, where $w$ is a suitable weight function on $[0, \infty)$, and $\|\cdot\|_p$ stands for the $L^p$ norm (when $p = 2$ we have usual Euclidean norm). We assume that $w$ is non-decreasing and continuous on $[0, \infty)$ with $w(\infty) = \infty$, and for $a, b \in \mathbb{R}^d$ satisfying $w(\|a + b\|) \leq w(\|a\|) + w(\|b\|)$. Examples of the weight functions are: $w(x) = a + bx, a, b > 0$ or $w(x) = x^\alpha$. The empirical version of the weighted $L^p$ depth is obtained by replacing distribution $F$ of $X$ in $\mathbb{E}w(\|x - X\|_p) = \int w(\|x - t\|_p)dF(t)$ by its empirical counterpart calculated from the sample $X^n$...

The Projection and Tukey’s depths are calculated using an approximate algorithm. Calculations of Mahalanobis, Euclidean and $L^p$ depths are exact. Returns the depth of multivariate point $u$ with respect to data set $X$.

**Author(s)**

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.

**References**


**See Also**

depthContour and depthPersp for depth graphics.

**Examples**

```r
library(robustbase)

# Calculation of Projection depth
data(starsCYG, package = "robustbase")
depth(t(colMeans(starsCYG)), starsCYG)

# Also for matrices
depth(starsCYG, starsCYG)

# Projection depth applied to a large bivariate data set
x <- matrix(rnorm(9999), nc = 3)
depth(x, x)
```
Description

Virtual class with structure for every depth class from depthproc package.

Slots

data set.  
X reference set.  
method depth type.

depthContour

Approximate depth contours

Description

Draws an approximate contours of depth for bivariate data.

Usage

depthContour(x, xlim = extendrange(x[, 1], f = 0.1), 
ylim = extendrange(x[, 2], f = 0.1), n = 50, pmean = TRUE, 
mcol = "blue", pdmedian = TRUE, mecol = "brown", legend = TRUE, 
points = FALSE, colors = heat_hcl, levels = 10, 
depth_params = list(), graph_params = list(), 
contour_method = c("auto", "convexhull", "contour")

Arguments

x Bivariate data 
xlim Determines the width of x-axis. 
ylim Determines the width of y-axis. 
n Number of points in each coordinate direction to be used in contour plot. 
pmean Logical. If TRUE mean will be marked. 
mcol Determines the color of lines describing the mean. 
pmedian Logical. If TRUE depth median will be marked. 
mecol Determines the color of lines describing the depth median. 
legend Logical. If TRUE legend for mean and depth median will be drawn. 
points Logical. If TRUE points from matrix x will be drawn. 
colors function for colors pallete (e.g. gray.colors).
levels number of levels for color scale.

depth_params list of parameters for function depth (method, threads, ndir, la, lb, pdim, mean, cov, exact).

graph_params list of graphical parameters for functions filled.contour and contour (e.g. lwd, lty, main).

contour_method determines the method used to draw the contour lines. The default value ("auto") tries to determine the best method for given depth function. "convexhull" uses a convex hull algorithm to determine boundaries. "contour" uses the algorithm from filled.contour.

Details

The set of all points that have depth at least \( \alpha \) is called \( \alpha \)-trimmed region. The \( \alpha \)-trimmed region w.r.t. \( F \) is denoted by \( D_\alpha(F) \), i.e.,

\[
D_\alpha(F) = \{ z \in \mathbb{R}^d : D(z, F) \geq \alpha \}.
\]

Author(s)

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.

See Also

depthPersp

Examples

```r
# EXAMPLE 1
set.seed(123)
x <- mvrnorm(1000, c(0, 0), diag(2))
depthContour(x, colors = gray.colors)
# with points
depthContour(x, points = TRUE)
depthContour(x, points = FALSE, levels = 10)

# EXAMPLE 2
data(inf.mort, maesles.imm)
data1990 <- na.omit(cbind(inf.mort[, 1], maesles.imm[, 1]))
depthContour(data1990, n = 50, pmean = TRUE, mcol = "blue",
pmedian = TRUE, mec = "brown", legend = TRUE, points = TRUE,
depth_params = list(method = "LP"),
graph_params = list(
  xlab = "infant mortality rate per 1000 live birth",
ylab = "against measles immunized percentage",
  main = "L2 depth, UN Fourth Goal 2011 year")
)

#EXAMPLE 3
data("france")
depthContour(france,
```
DepthCurve-class

```r
depth_params = list(method = "Tukey"),
points = TRUE
)
```

---

**DepthCurve-class**

**DepthCurve**

---

**Description**

This page describes mechanism behavior of ScaleCurve and AsymmetryCurve.

**Details**

DepthCurve is a virtual class that contains methods (getPlot(...) and plot(...)) for rendering single curve such as ScaleCurve or AsymmetryCurve. Such object can be combined by overloaded operator '+'

**Slots**

- **depth** object of Depth-class
- **name** name of dataset used on plot
- **title** title of a plot
- **alpha** central area values

**Examples**

```r
library(mvtnorm)
x <- mvrnorm(n = 100, mu = c(0, 0), Sigma = 2 * diag(2))
y <- rmvtt(n = 100, sigma = diag(2), df = 4)
s1 <- scaleCurve(x, depth_params = list(method = "Projection"))
s2 <- scaleCurve(y, depth_params = list(method = "Projection"), name = "Set2")
sc_list <- combineDepthCurves(s1, s2) # Add one curve to another
plot(sc_list) # Draw plot with two curves
z <- mvrnorm(n = 100, mu = c(0, 0), Sigma = 1 * diag(2))
s3 <- scaleCurve(z, depth_params = list(method = "Projection"))
plot(combineDepthCurves(sc_list, s3)) # Add third curve and draw a plot
```
DepthCurveList-class  DepthCurveList

Description

DepthCurveList is a special container for DepthCurve objects. See DepthCurve-class

depthDensity  Depth weighted density estimator

Description

Experimental function used to fit depth weighted density estimator.

Usage

depthDensity(x, y, nx = 5, ny = 32, xg = NULL, yg = NULL, ...)

Arguments

x  numeric vector
y  numeric vector
nx  the number of equally spaced points at which the density is to be estimated in x-dimension.
ny  the number of equally spaced points at which the density is to be estimated in x-dimension.
xg  vector of point at which the density is to be estimated.
yg  vector of point at which the density is to be estimated.
...  arguments passed to depthLocal.

References


Examples

## Not run:
# .sampleData is special function for creating
data for testing conditional density estimators
data <- DepthProc::sampleData(1:5, 100)
x <- data[, 1]
y <- data[, 2]
plot(x, y)
dep <- depthDensity(x, y)
plot(dep, type = "raw")
plot(dep, type = "depth")

## End(Not run)

---

**DepthDensity-class**

**DepthDensity**

**Description**

Class for depth based density estimator.

**Details**

`depthDensity`

---

**depthEuclid**

**Euclidean Depth**

**Description**

Computes the euclidean depth of a point or vectors of points with respect to a multivariate data set.

**Usage**

`depthEuclid(u, X)`

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>u</td>
<td>Numerical vector or matrix whose depth is to be calculated. Dimension has to be the same as that of the observations.</td>
</tr>
<tr>
<td>X</td>
<td>The data as a matrix, data frame or list. If it is a matrix or data frame, then each row is viewed as one multivariate observation. If it is a list, all components must be numerical vectors of equal length (coordinates of observations).</td>
</tr>
<tr>
<td>...</td>
<td>currently not supported.</td>
</tr>
</tbody>
</table>

**Details**

Calculation of Euclidean depth is exact.

Returns the depth of multivariate point u with respect to data set X.
### depthLocal

**Author(s)**

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.

**Examples**

```r
x <- matrix(rnorm(9999), nc = 3)
depthEuclid(x, x)
```

---

### Local depth

**Description**

Computes local version of depth according to proposals of Paindaveine and Van Bever — see references.

**Usage**

```r
depthLocal(u, X, beta = 0.5, depth_params1 = list(method =
"Projection"), depth_params2 = depth_params1)
```

**Arguments**

- **u**: Numerical vector or matrix whose depth is to be calculated. Dimension has to be the same as that of the observations.
- **X**: The data as a matrix, data frame. If it is a matrix or data frame, then each row is viewed as one multivariate observation.
- **beta**: Cutoff value for neighbourhood.
- **depth_params1**: List of parameters for function depth (method, threads, ndir, la, lb, pdim, mean, cov, exact).
- **depth_params2**: As above — default is depth_params1.

**Details**

A successful concept of local depth was proposed by Paindaveine and Van Bever (2012). For defining a neighbourhood of a point authors proposed using idea of symmetrisation of a distribution (a sample) with respect to a point in which depth is calculated. In their approach instead of a distribution $P^X$, a distribution $P_x = \frac{1}{2}P^X + \frac{1}{2}P^{2X-x}$ is used. For any $\beta \in [0, 1]$, let us introduce the smallest depth region bigger or equal to $\beta$,

$$R^\beta(F) = \bigcap_{\alpha \in A(\beta)} D_\alpha(F),$$

where $A(\beta) = \{\alpha \geq 0 : P[D_\alpha(F)] \geq \beta\}$. Then for a locality parameter $\beta$ we can take a neighbourhood of a point $x$ as $R^\beta_x(P)$. 
Formally, let $D(\cdot, P)$ be a depth function. Then the local depth with the locality parameter $\beta$ and w.r.t. a point $x$ is defined as

$$LD^\beta(z, P) : z \rightarrow D(z, P^\beta_x),$$

where $P^\beta_x(\cdot) = P(\cdot | R^\beta_x(P))$ is cond. distr. of $P$ conditioned on $R^\beta_x(P)$.

**References**


**Examples**

```r
## Not run:
# EXAMPLE 1
data <- mvrnorm(100, c(0, 5), diag(2) * 5)
# By default depth_params2 = depth_params1
depthLocal(data, data, depth_params1 = list(method = "LP"))
depthLocal(data, data, depth_params1 = list(method = "LP"),
    depth_params2 = list(method = "Projection"))
# Depth contour
depthContour(data, depth_params = list(method = "Local", depth_params1 = list(method = "LP")))

# EXAMPLE 2
data(inf.mort, maesles.imm)
data1990 <- na.omit(cbind(inf.mort[, 1], maesles.imm[, 1]))
depthContour(data1990,
    depth_params = list(
        method = "Local",
        depth_params1 = list(method = "LP"),
        beta = 0.3
    ))

# EXAMPLE 3
Sigma1 <- matrix(c(10, 3, 3, 2), 2, 2)
X1 <- mvrnorm(n = 8500, mu = c(0, 0), Sigma1)
Sigma2 <- matrix(c(10, 0, 0, 2), 2, 2)
X2 <- mvrnorm(n = 1500, mu = c(-10, 6), Sigma2)
BALLOT <- rbind(X1, X2)

train <- sample(1:10000, 100)
data <- BALLOT[train,]
depthContour(data,
    depth_params = list(
        method = "Local",
        beta = 0.3,
        depth_params1 = list(method = "Projection")
    ))
```

## End(Not run)
**depthLP**

*LP Depth*

**Description**

Computes the LP depth of a point or vectors of points with respect to a multivariate data set.

**Usage**

```r
depthLP(u, X, pdim = 2, la = 1, lb = 1, threads = -1, func = NULL)
```

**Arguments**

- **u**: Numerical vector or matrix whose depth is to be calculated. Dimension has to be the same as that of the observations.
- **X**: The data as a matrix, data frame or list. If it is a matrix or data frame, then each row is viewed as one multivariate observation. If it is a list, all components must be numerical vectors of equal length (coordinates of observations).
- **pdim**: dimension used in calculating depth function.
- **la**: slope the weighing function.
- **lb**: intercept in the weighing function.
- **threads**: number of threads used in parallel computations. Default value -1 means that all possible cores will be used.
- **func**: the weighing function. Currently it is not supported.

**Details**

Returns the depth of multivariate point u with respect to data set X.

**Author(s)**

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.

**Examples**

```r
x <- matrix(rnorm(3000), ncol = 3)

# Same results
depthLP(x, x, pdim = 2)
```
depthMah

Description

Computes the mahalanobis depth of a point or vectors of points with respect to a multivariate data set.

Usage

depthMah(u, X, cov = NULL, mean = NULL, threads = -1)

Arguments

- **u**: Numerical vector or matrix whose depth is to be calculated. Dimension has to be the same as that of the observations.
- **X**: The data as a matrix, data frame or list. If it is a matrix or data frame, then each row is viewed as one multivariate observation. If it is a list, all components must be numerical vectors of equal length (coordinates of observations).
- **cov**: Custom covariance matrix passed. If NULL standard calculations will be based on standard covariance estimator.
- **mean**: Custom mean vector. If null — mean average will be used.
- **threads**: Number of threads used in parallel computations. Default value -1 means that all possible cores will be used.

Details

Calculation of Mahalanobis depth is exact.

Returns the depth of multivariate point u with respect to data set X.

Author(s)

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.

Examples

```r
x <- matrix(rnorm(9999), nc = 3)
depthMah(x, x)
```
## depthMedian

### Description

Return point with maximum depth function value. If multiple points have the same value, mean average of them will be returned.

### Usage

```r
depthMedian(x, depth_params = list(), convex = FALSE)
```

```r
## S4 method for signature 'matrix'
depthMedian(x, depth_params = list(),
            convex = FALSE)
```

```r
## S4 method for signature 'data.frame'
depthMedian(x, depth_params = list(),
            convex = FALSE)
```

```r
## S4 method for signature 'Depth'
depthMedian(x, convex = FALSE)
```

### Arguments

- `x`: object of class Depth or matrix.
- `depth_params`: list of parameters for function depth (method, threads, ndir, la, lb, pdim, mean, cov, exact).
- `convex`: logical. If true, than centroid of the convex hull created from deepest points is returned.

### Examples

```r
# depthMedian for matrix
x <- matrix(rnorm(600), nc = 3)
depthMedian(x)
```

```r
dp <- depth(x)
depthMedian(dp)
```
depthPersp

**Perspective plot for depth functions**

**Description**

Draws a perspective plot of depth function over x-y plane.

**Usage**

```r
depthPersp(x, plot_method = \"lattice\", xlim = extendrange(x[, 1], f = 0.1), ylim = extendrange(x[, 2], f = 0.1), n = 50, xlab = \"x\", ylab = \"y\", plot_title = NULL, colors = heat_hcl, depth_params = list(), graph_params = list())
```

**Arguments**

- **x**: bivariate data
- **plot_method**: there are two options "lattice", and "rgl" — see details
- **xlim**: limits for x-axis
- **ylim**: limits for y-axis
- **n**: number of points that will be used to create plot \( (n^2) \)
- **xlab**: description of x-axis
- **ylab**: description of y-axis
- **plot_title**: plot title (default NULL means paste(depth_params$method, \"depth\"))
- **colors**: function for colors pallete (e.g. gray.colors).
- **depth_params**: list of parameters for function depth ("method", "threads", "ndir", "la", "lb", "pdim", "mean", "cov", "exact").
- **graph_params**: list of graphical parameters for functions rgl::persp3d and lattice::wireframe.

**Details**

plot_method — rgl package is not in depends list because it may cause problems when OpenGL is not supported. To use plot_method = \"rgl\" you must load this package on your own.

**Author(s)**

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.
Examples

# EXAMPLE 1
x <- mvrnorm(100, c(0, 0), diag(2))
depthPersp(x, depth_params = list(method = "Euclidean"))

# EXAMPLE 2
data(inf.mort, maesles.imm)
data1990 <- na.omit(cbind(inf.mort[,1], maesles.imm[,1]))

## Not run:
library(rgl)
depthPersp(data1990, plot_method = "rgl",
            depth_params = list(method = "Projection"))

## End(Not run)

---

depthProjection  Projection Depth

Description
Computes the Projection depth of a point or vectors of points with respect to a multivariate data set.

Usage
depthProjection(u, X, ndir = 1000, threads = -1)

Arguments
- **u**: Numerical vector or matrix whose depth is to be calculated. Dimension has to be the same as that of the observations.
- **X**: The data as a matrix, data frame or list. If it is a matrix or data frame, then each row is viewed as one multivariate observation. If it is a list, all components must be numerical vectors of equal length (coordinates of observations).
- **ndir**: number of directions used in computations
- **threads**: number of threads used in parallel computations. Default value -1 means that all possible cores will be used.
- **...**: currently not supported.

Details
Irrespective of dimension, Projection and Tukey’s depth is obtained by approximate calculation. Returns the depth of multivariate point u with respect to data set X.
depthTukey

Author(s)

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.

Examples

```R
x <- matrix(rnorm(3000), nc = 3)
a <- depthProjection(x, x, ndir = 2000)
```

<table>
<thead>
<tr>
<th>depthTukey</th>
<th>Tukey Depth</th>
</tr>
</thead>
</table>

Description

Computes the Tukey depth of a point or vectors of points with respect to a multivariate data set.

Usage

```R
depthTukey(u, X, ndir = 1000, threads = -1, exact = FALSE)
```

Arguments

- `u` Numerical vector or matrix whose depth is to be calculated. Dimension has to be the same as that of the observations.
- `X` The data as a matrix, data frame or list. If it is a matrix or data frame, then each row is viewed as one multivariate observation. If it is a list, all components must be numerical vectors of equal length (coordinates of observations).
- `ndir` number of directions used in computations
- `threads` number of threads used in parallel computations. Default value -1 means that all possible cores will be used.
- `exact` if TRUE exact algorithm will be used. Currently it works only for 2 dimensional data set.
- `...` currently not supported.

Details

Irrespective of dimension, Projection and Tukey’s depth is obtained by approximate calculation.

Returns the depth of multivariate point `u` with respect to data set `X`.

Author(s)

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.
Examples

## Not run:
```r
x <- matrix(rnorm(3000), nc = 3)
depthTukey(x, ndir = 2000)
```

## End(Not run)

# Exact algorithm in 2d
```r
x <- matrix(rnorm(2000), nc = 2)
depthTukey(x, exact = TRUE)
```

---

fncBoxPlot

Functional boxplot based on Modified Band Depth

Description

Functional boxplot based on Modified Band Depth

Usage

```r
fncBoxPlot(u, x = NULL, bands = c(0, 0.5), method = "MBD", byrow = NULL, ...)
```

Arguments

- `u`: data matrix
- `x`: reference set. If null `u` will be used as reference.
- `bands`: limits for bands
- `method`: depth method
- `byrow`: `byrow`
- `...`: other arguments passed to fncDepth

Examples

```r
# some data:
x <- matrix(rnorm(200), ncol = 10)

fncBoxPlot(x, bands = c(0, 0.5, 1), method = "FM")
fncBoxPlot(x, bands = c(0, 0.5, 1), method = "FM", byrow = FALSE)

colnames(x) <- paste0("f", 1:ncol(x))
fncBoxPlot(x, bands = c(0, 0.5, 1), method = "FM")

# fncBoxPlot handles zoo and xts objects
library(xts)
```
**fncDepth**

Basic function for functional depths

Description

Calculates depth functions.

Usage

```r
fncDepth(u, X = NULL, method = "MBD", byrow = NULL, ...)
```

## S3 method for class 'matrix'
```
fncDepth(u, X = NULL, method = "MBD", byrow = NULL, ...)
```

## S3 method for class 'zoo'
```
fncDepth(u, X = NULL, method = "MBD", byrow = NULL, ...)
```

Arguments

- **u**
  - data
- **X**
  - reference set. If null u will be used as reference.
- **method**
  - depth method - "MBD" (default), or "FM" (Frainman-Muniz depth)
- **byrow**
  - logical or character.
- **...**
  - additional arguments passed to fncDepthFM.

Examples

```r
x <- matrix(rnorm(200), ncol = 10)
time <- as.POSIXct(1:ncol(x) * 86400, origin = "1970-01-01")
x_xts <- xts(x(time), order.by = time)
fncBoxPlot(x_xts, bands = c(0, 0.5, 1), method = "FM")
data("katowice.airpollution")
pl <- fncBoxPlot(katowice.airpollution, bands = c(0, 0.5, 1), method = "MBD")
pl + ggtitle("Air pollution in Katowice") + labs(y = "pollination", x = "hour")
```
### fncDepthFM

**FM Depth**

**Description**
Computes Frainman-Muniz depth for functional data.

**Usage**

```r
fncDepthFM(u, X, dep1d_params = list(method = "Projection"))
```

**Arguments**

- **u**: Numerical vector or matrix whose depth is to be calculated. Dimension has to be the same as that of the observations.
- **X**: The data as a matrix. If it is a matrix or data frame, then each row is viewed as one multivariate observation.
- **dep1d_params**: parameters passed to depth function used in one dimension.
- **...**: other arguments passed to depth function.

**Examples**

```r
x <- matrix(rnorm(60), nc = 20)
fncDepthFM(x)
```

### fncDepthMBD

**Modified band depth**

**Description**
Computes the modified band depth.

**Usage**

```r
fncDepthMBD(u, X)
```

**Arguments**

- **u**: Numerical vector or matrix whose depth is to be calculated. Dimension has to be the same as that of the observations.
- **X**: The data as a matrix. If it is a matrix or data frame, then each row is viewed as one multivariate observation.
**fncDepthMedian**

**Examples**

```r
x <- matrix(rnorm(600), nc = 20)
fncDepthMedian(x)
fncDepthMedian(x, x)
```

---

**fncDepthMedian**  
*Functional median*

**Description**

Calculate functional median based on data depth.

**Usage**

```r
fncDepthMedian(u, X = NULL, method = "MBD", byrow = NULL,
unique = TRUE, ...)
```

**Arguments**

- `u`: data matrix
- `X`: reference set. If null `u` will be used as reference.
- `method`: depth method
- `byrow`: byrow
- `unique`: if true
- `...`: other arguments passed to `fncDepth`  

**Examples**

```r
x <- matrix(rnorm(600), nc = 20)
md <- fncDepthMedian(x, method = "FM", dep1d = "Mahalanobis")
```
fncGetBand  *Functional bands*

**Description**

Extract bands from functional depth object.

**Usage**

```r
fncGetBand(obj, band = 0.5)
```

**Arguments**

- `obj` object that inherits from FunctionalDepth.
- `band` single numeric value.

**Examples**

```r
x <- matrix(rnorm(600), nc = 20)
obj <- fncDepth(x, method = "FM", dep1d = "Mahalanobis")
fncGetBand(obj)
```

---

france  *Relation between minimum wage (MW) and unemployment rate (UR) in France.*

**Description**

Relation between minimum wage (MW) and unemployment rate (UR) in France.

**Usage**

```r
data(france)
```

**Format**

Data frame containing 17 rows and two column. MW is a minimum wage, and UR is an unemployment rate.
FunctionalDepth-class  

Functional Depth

Description

Virtual class with structure for every functional depth class from depthproc package. Inherits from Depth-class.

Slots

index  numeric, or time-based object.

getPlot  

Create ggplot object from DepthCurve, DepthCurveList and DDPlot classes.

Description

Create an object of class ggplot from DepthCurve and DepthCurveList.

Usage

getPlot(object)

## S4 method for signature 'AsymmetryCurveList'
getPlot(object)

## S4 method for signature 'DDPlot'
getPlot(object)

## S4 method for signature 'ScaleCurveList'
getPlot(object)

Arguments

object  a DDPlot ScaleCurve or AsymmetryCurve object class.
### inf.mort

**Infant mortality rate (0–1 year) per 1,000 live births**

**Description**

Infant mortality rate (0–1 year) per 1,000 live births

**Usage**

```r
data(inf.mort)
```

**Format**

A data frame with 654 rows and 4 variables

**Source**


---

### internet.users

**Internet view data**

**Description**

Internet view data

**Usage**

```r
data(internet.users)
```

**Format**

Data frame containing 17518 rows and 6 columns — 17518 working days of the Internet service considered with respect to variables: service, month, day, hour, unique users and page views.

**References**

**Description**

Air pollution in Katowice city by hour.

**Usage**

```r
data("katowice.airpollution")
```

**Format**

data frame containing 181 rows (days) and 24 columns. Each column is an air pollution for given hour.

---

**lsdAddContour**

*Adds location scale depth contour to the existing plot.*

---

**Description**

This function adds one location-scale contour to the existing plot.

**Usage**

```r
lsdAddContour(x, cont = NULL, ...)
```

---

**Arguments**

- `x` object of class LSDepthContour
- `cont` depth of contour to plot
- `...` other arguments passed to polygon function

---

**Examples**

```r
smp <- rf(100, 5, 10)
x <- lsdSampleDepthContours(smp)
plot(x)
lsdAddContour(x, 0.1, col = "grey50")
lsdAddContour(x, 0.3, col = "grey10", border = "red", lwd = 4)
```
**LSDepth-class**  
*Location-Scale depth class*

**Description**

Class used to store maximum location-scale depth results.

**Slots**

- `max_depth` maximum Student depth value.
- `mu` location estimate in the deepest point.
- `sigma` scale estimate in the deepest point.

**LSDepthContour-class**  
*Location-Scale depth contour class*

**Description**

Class used to store result of location-scale depth contours.

**Slots**

- `cont_depth` depth values used to calculate contours.
- `sample` original sample used to calculate depth contours.
- `.Data` list with estimated values of scale-depth contours.

**lsdGetContour**  
*Get location-scale contour from LSDepthContour object.*

**Description**

Get numeric values of the location-scale depth contour from existing object of LSDepthContour class.

**Usage**

```r
lsdGetContour(x, cont)
```

```r
## S4 method for signature 'LSDepthContour'
lsdGetContour(x, cont)
```
Arguments

\begin{itemize}
\item \texttt{x} \hspace{1cm} \text{object of class \texttt{LSDepthContour}}
\item \texttt{cont} \hspace{1cm} \text{single numeric \textendash{} depth of contour to return}
\end{itemize}

Details

Calculations are based on \texttt{lsdepth} algorithm written by Ch. Muller.

Examples

```r
dcont <- lsdsampledepthcontours(rf(200, 4, 7), depth = c(0.1, 0.2))

# get contour that is present in dcont object
lsdgetcontour(dcont, 0.1)

# get contour that is not present in dcont
# it will be automatically calculated
lsdgetcontour(dcont, 0.3)
```

\textbf{lsdsampledepthcontours}

\emph{Calculate sample Mizera and Muller Student depth contours}

Description

Calculate sample one-dimensional Mizera and Muller Student depth contours.

Usage

```r
lsdsampledepthcontours(x, depth = c(0.1, 0.2, 0.3, 0.4),
                        lengthmu = 1000)
```

Arguments

\begin{itemize}
\item \texttt{x} \hspace{1cm} \text{one dimensional vector with sample}
\item \texttt{depth} \hspace{1cm} \text{depth level for contours}
\item \texttt{lengthmu} \hspace{1cm} \text{number of points to evaluate depth}
\end{itemize}

Details

Calculations are based on \texttt{lsdepth} algorithm written by Ch. Muller.

References

# Examples

```r
# EXAMPLE 1
# F-distribution
dcont <- lsSampleDepthContours(rf(200, 4, 7))
plot(dcont)

# EXAMPLE 2
# normal distribution - more contours calculated
dcont_norm <- lsSampleDepthContours(rnorm(100), seq(0.05, 0.4, 0.05))
plot(dcont_norm)
```

## Description

Calculates the maximum Student depth estimator of location and scale for one dimensional data (an alternative for MED and MAD or for the mean and standard deviation).

## Usage

```r
lsSampleMaxDepth(x, iter = 100, eps = 1e-04, p_length = 10)
```

## Arguments

- **x**: one dimensional vector with sample
- **iter**: maximum number of iterations in algorithm for calculation Location-Scale Depth
- **eps**: tolerance level
- **p_length**: is the maximum length of the precision step at the end

## Details

Calculations are based on lsdepth algorithm written by Ch. Muller.

## References


## Examples

```r
x <- rnorm(100)
lsSampleMaxDepth(x)
y <- rf(100, 4, 10)
lsSampleMaxDepth(y)
```
maesles.imm

Children 1 year old immunized against measles, percentage

Description

Children 1 year old immunized against measles, percentage

Usage

data(maesles.imm)

Format

A data frame with 654 rows and 4 variables

Source


---

mwilcoxontest

Multivariate Wilcoxon test for equality of dispersion.

Description

Depth based multivariate Wilcoxon test for a scale difference.

Usage

mwilcoxontest(x, y, alternative = "two.sided", depth_params = list())

Arguments

x  
data matrix

y  
data matrix

alternative  
a character string specifying the alternative hypothesis, must be one of "two.sided" (default), "greater" or "less".

depth_params  
list of parameters for function depth (method, threads, ndir, la, lb, pdim, mean, cov, exact).
Details

Having two samples $X^n$ and $Y^m$ using any depth function, we can compute depth values in a combined sample $Z^{n+m} = X^n \cup Y^m$, assuming the empirical distribution calculated basing on all observations, or only on observations belonging to one of the samples $X^n$ or $Y^m$.

For example if we observe $X'_l$'s depths are more likely to cluster tightly around the center of the combined sample, while $Y'_l$'s depths are more likely to scatter outlying positions, then we conclude $Y^m$ was drawn from a distribution with larger scale.

Properties of the DD plot based statistics in the i.i.d setting were studied by Li & Liu (2004). Authors proposed several DD-plot based statistics and presented bootstrap arguments for their consistency and good effectiveness in comparison to Hotelling $T^2$ and multivariate analogues of Ansari-Bradley and Tukey-Siegel statistics. Asymptotic distributions of depth based multivariate Wilcoxon rank-sum test statistic under the null and general alternative hypotheses were obtained by Zuo & He (2006). Several properties of the depth based range test involving its unbiasedness was critically discussed by Jureckova & Kalina (2012). Basing on DD-plot object, which is available within the DepthProc it is possible to define several multivariate generalizations of one-dimensional rank and order statistics in an easy way. These generalizations cover well known Wilcoxon rank-sum statistic.

The depth based multivariate Wilcoxon rang sum test is especially useful for the multivariate scale changes detection and was introduced among other by Liu & Singh (2003) and intensively studied by Jureckowa & Kalina (2012) and Zuo & He (2006) in the i.i.d. setting.

For the samples $X^m = \{X_1, ..., X_m\}$, $Y^n = \{Y_1, ..., Y_n\}$, their $d_1^X, ..., d_m^X, d_1^Y, ..., d_n^Y$ depths w.r.t. a combined sample $Z = X^n \cup Y^m$ the Wilcoxon statistic is defined as $S = \sum_{i=1}^{m} R_i$, where $R_i$ denotes the rang of the i-th observation, $i = 1, ..., m$ in the combined sample $R(y_l) = \# \{z_j \in Z : D(z_j, Z) \leq D(y_l, Z)\}, l = 1, ..., m$.

The distribution of $S$ is symmetric about $E(S) = \frac{1}{2}m(m + n + 1)$, its variance is $D^2(S) = \frac{1}{12}mn(m + n + 1)$.

References


Examples

```r
# EXAMPLE 1
x <- mvrnorm(100, c(0, 0), diag(2))
y <- mvrnorm(100, c(0, 0), diag(2) * 1.4)
mWilcoxonTest(x, y)
mWilcoxonTest(x, y, depth_params = list(method = "LP"))

# EXAMPLE 2
data(under5.mort)
```
```r
data(inf.mort)
data(maesles.imm)
data2011 <- na.omit(cbind(under5.mort[, 22], inf.mort[, 22], maesles.imm[, 22]))
data1990 <- na.omit(cbind(under5.mort[, 1], inf.mort[, 1], maesles.imm[, 1]))
mWilcoxonTest(data2011, data1990)
```

---

**plot**

*Method for plotting DepthCurve and DDPlot object.*

---

**Description**

Plot Depth curve

**Usage**

```r
plot(x, y, ...)
```

```r
## S4 method for signature 'DDPlot,ANY'
plot(x)
```

```r
## S4 method for signature 'DepthCurve,ANY'
plot(x)
```

```r
## S4 method for signature 'DepthCurveList,ANY'
plot(x)
```

**Arguments**

- `x` object that inherits from DepthCurve class (ScaleCurve or AsymmetryCurve), or DDPlot class.
- `y` not supported.
- `...` not supported.

**Examples**

```r
x <- mvrnorm(n = 100, mu = c(0, 0), Sigma = 3 * diag(2))
s <- scaleCurve(x)
plot(s)
```
plot,BinnDepth2d,ANY-method

2d Binning plot

Description

Binning 2d

Usage

## S4 method for signature 'BinnDepth2d,ANY'
plot(x, ..., alpha = 0.1, bg_col = "red",
     add_mid = TRUE)

Arguments

x          object of class BinnDepth2d
...
alpha      alpha value for rgb function
bg_col     background color
add_mid    logical. If TRUE centers of bins will be marked.

See Also

depth

Examples

tmp <- binningDepth2D(x = mvrnorm(100, rep(0, 2), diag(2)))
plot(tmp)

---

plot,DepthDensity,ANY-method

Plot function for DepthDensity.

Description

Create plot for DepthDensity. See depthDensity for more information.

Usage

## S4 method for signature 'DepthDensity,ANY'
plot(x, type = "depth", ...)

---
Arguments

- **x**: object of class `DepthDensity`
- **type**: type of density that will be plotted. "depth" is a depth scaled density, and "raw" is density without scaling.
- **...**: graphical arguments.

Description

Create location-scale depth plot. See `lsdSampleDepthContours` for more information.

Usage

```r
## S4 method for signature 'LSDepthContour,ANY'
plot(x, cont = NULL, ratio = 1,
     mu_min = NULL, mu_max = NULL, col = NULL, border = NULL, ...)
```

Arguments

- **x**: object of class `LSDepthContour`
- **cont**: plotted contours. Default NULL means that all contours stored in x will be plotted.
- **ratio**: ratio
- **mu_min**: mu_min
- **mu_max**: mu_max
- **col**: vectors with area colors passed to polygon function
- **border**: vector with colors for borders
- **...**: other parameters passed to polygon

Examples

```r
smp <- rf(100, 5, 10)
x <- lsdSampleDepthContours(smp)
plot(x, col = paste0("grey", col = rev(seq(10, 40, 10))))
```
RobReg-class  

---

**RobReg**

**Description**

Virtual class for robust regression methods from depthproc package

**Slots**

coeff  coefficients of fitted model

---

runifsphere  

---

**Random number generation from unit sphere.**

**Description**

This function generates random numbers from p-dimensional unit sphere.

**Usage**

runifsphere(n, p = 2)

**Arguments**

n  number of random samples.

p  dimension of the unit sphere.

**Author(s)**

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.

**Examples**

```r
x <- runifsphere(n = 100)
plot(x)
```
scaleCurve

Description

Draws a scale curve: measure of dispersion.

Usage

scaleCurve(x, y = NULL, alpha = seq(0, 1, 0.01), name = "X",
alpha_y = "Y", title = "Scale Curve", depth_params = list(method =
"Projection"))

Arguments

x Multivariate data as a matrix.
y Additional matrix with multivariate data.
alpha Vector with values of central area to be used in computation.
name Name of matrix X used in legend.
name_y Name of matrix Y used in legend.
title title of the plot.
depth_params list of parameters for function depth (method, threads, ndir, la, lb, pdim, mean,
cov, exact).

Details

For sample depth function \( D(x, Z^n) \), \( x \in \mathbb{R}^d, d \geq 2, Z^n = \{z_1, \ldots, z_n\} \subset \mathbb{R}^d, D_\alpha(Z^n) \) denoting \( \alpha \) — central region, we can define the scale curve \( SC(\alpha) = (\alpha, \text{vol}(D_\alpha(Z^n))) \subset \mathbb{R}^2 \), for \( \alpha \in [0, 1] \)

The scale curve is a two-dimensional method of describing the dispersion of random vector around the depth induced median.

Function scalecurve for determining the volumes of the convex hull containing points from alpha central regions, uses function convhulln from geometry package.

The minimal dimension of data in X or Y is 2.

ggplot2 package is used to draw a plot.

Value

Returns the volume of the convex hull containing subsequent central points of X.

Author(s)

Daniel Kosiorowski, Mateusz Bocian, Anna Wegrzynkiewicz and Zygmunt Zawadzki from Cracow University of Economics.
References


See Also

depthContour and depthPersp for depth graphics.

Examples

```r
library(mvtnorm)
x <- mvrnorm(n = 100, mu = c(0, 0), Sigma = 3 * diag(2))
y <- rmvt(n = 100, sigma = diag(2), df = 2)
scaleCurve(x, y, depth_params = list(method = "Projection"))
# Comparing two scale curves
# normal distribution and mixture of normal distributions
x <- mvrnorm(100, c(0, 0), diag(2))
y <- mvrnorm(80, c(0, 0), diag(2))
z <- mvrnorm(20, c(5, 5), diag(2))
scaleCurve(x, rbind(y, z), name = "N", name_y = "Mixture of N",
  depth_params = list(method = "Projection"))
```

ScaleCurve-class

ScaleCurve and ScaleCurveList

Description

ScaleCurve is a class that stores results of scaleCurve function.

Details

ScaleCurve intherits behviour from numeric vector, so raw values of ScaleCurve can be accessed via as.numeric(...).

The mechanism of creating plots with multiple curves is shown in DepthCurve-class (same mechanism is applied for AsymmetryCurve).

Examples

```r
library(mvtnorm)
x <- mvrnorm(n = 100, mu = c(0, 0), Sigma = 2 * diag(2))
y <- rmvt(n = 100, sigma = diag(2), df = 4)
s1 <- scaleCurve(x, depth_params = list(method = "Projection"))
s2 <- scaleCurve(y, depth_params = list(method = "Projection"), name = "Set2")
```
sc_list <- combineDepthCurves(s1, s2) # Add one curve to another
plot(sc_list) # Draw plot with two curves

z <- mvrnorm(n = 100, mu = c(0, 0), Sigma = 1 * diag(2))
s3 <- scaleCurve(z, depth_params = list(method = "Projection"))
plot(combineDepthCurves(sc_list, s3)) # Add third curve and draw a plot

trimProjReg2d

Description
Computes projection trimmed regression in 2 dimensions.

Usage
trimProjReg2d(x, y, alpha = 0.1)

Arguments
x
  Independent variable
y
  Dependent variable
alpha
  Percentage of trimmed observations

Author(s)
Zygmunt Zawadzki from Cracow University of Economics.

Examples

# EXAMPLE 1
data(pension)
plot(pension)
abline(lm(Reserves ~ Income, data = pension), lty = 3, lwd = 2) # lm
abline(trimProjReg2d(pension[, 1], pension[, 2]), lwd = 2) # trimprojreg2d
legend("bottomright", c("OLS", "TrimLS"), lty = 1:2)

# EXAMPLE 2
data(under5.mort)
data(inf.mort)
data(maesles.imm)
data2011 <- na.omit(cbind(under5.mort[, 22], inf.mort[, 22],
                      maesles.imm[, 22]))
x <- data2011[, 3]
y <- data2011[, 2]
plot(x, y, cex = 1.2, ylab = "infant mortality rate per 1000 live birth",
xlab = "against measles immunized percentage",
main = "Projection Depth Trimmed vs. LS regressions")
abline(lm(x ~ y), lwd = 2, col = "black") # lm
abline(trimProjReg2d(x, y), lwd = 2, col = "red") # trimmed reg
legend("bottomleft", c("LS", "TrimReg"), fill = c("black", "red"), cex = 1.4,
  bty = "n")

### Comparsion of a few regression methods ###
library(DepthProc)
library(MASS)

data("france")
plot(UR ~ MW, pch = 19, data = france)

# linear regression
lm.fit <- lm(UR ~ MW, data = france)
abline(lm.fit, lwd=2, cex=3, col='red')

# M-estimator
rlm.fit <- rlm(UR ~ MW, data = france)
abline(rlm.fit, lwd = 2, col = "blue")

# LMS
lqs.lms <- lqs(UR ~ MW, method = "lms", data = france) #least median of squares#
lqs.lts <- lqs(UR ~ MW, method = "lts", data = france) #least trimmed squares#
abline(lqs.lms, lwd = 2, col="green")
abline(lqs.lts, lwd = 2, col="pink")

# Lowess
lines(lowess(france$MW, france$UR, f = 0.5, iter = 0), lwd = 2) # loess

# Depth trimmed regression
trim.reg <- trimProjReg2d(france$MW, france$UR) #trimprojreg2d
abline(trim.reg, lwd = 4, col = 'orange')

---

**TrimReg2d-class**

**TrimReg2d**

**Description**

Class for robust regression methods from depthproc package
**under5.mort**  
Children under 5 months mortality rate per 1,000 live births

**Description**  
Children under 5 months mortality rate per 1,000 live births

**Usage**  
data(under5.mort)

**Format**  
A data frame with 654 rows and 4 variables

**Source**  

**USLABOUR**  
US Labour dataset

**Description**  
US Labour dataset

**Usage**  
data(USLABOUR)

**Format**  
A data frame with 654 rows and 4 variables

**Source**  
U.S. Department of Labor — Bureau of Labour Statistics FRED
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