Package ‘DepthProc’

September 2, 2018

Version 2.0.4
Date 2018-09-02
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.
License GPL-2
Depends R (>= 3.0.0), ggplot2, Rcpp (>= 0.11.2), rrcov, methods, MASS, np
Imports lattice, sm, geometry, colorspace, zoo
Suggests mvtnorm, rgl, sn, robustbase, dplyr, RcppArmadillo, xts, covr, testthat, fda, lintr
LinkingTo Rcpp, RcppArmadillo
SystemRequirements C++11
RoxygenNote 6.1.0
NeedsCompilation yes
Author Zygmunt Zawadzki [aut, cre], Daniel Kosiorowski [aut], Krzysztof Slomczynski [ctb], Mateusz Bocian [ctb], Anna Wegrzynkiewicz [ctb]
Maintainer Zygmunt Zawadzki <zygmunt@zstat.pl>
Repository CRAN
Date/Publication 2018-09-02 15:30:05 UTC
R topics documented:

abline.RobReg-method ........................................ 3
as.matrix ....................................................... 4
asymmetryCurve .................................................. 4
AsymmetryCurve-class ........................................... 6
BinnDepth2d-class ................................................ 6
binningDepth2D .................................................... 7
combineDepthCurves ............................................. 9
CovDepthWeighted-class ....................................... 9
CovLP .............................................................. 10
cracow.airpollution ............................................. 11
ddmvnorm .......................................................... 12
ddPlot .............................................................. 13
DDPlot-class ....................................................... 14
deepReg2d .......................................................... 15
DeepReg2d-class ................................................... 16
depth ............................................................... 17
Depth-class .......................................................... 19
depthContour ....................................................... 19
DepthCurve-class .................................................. 21
DepthCurveList-class ............................................ 21
depthDensity ........................................................ 22
DepthDensity-class ............................................... 23
depthEuclid .......................................................... 23
depthLocal ........................................................... 24
depthLP .............................................................. 25
depthMah ............................................................. 26
depthMedian .......................................................... 27
depthPersp ........................................................... 28
depthProjection ..................................................... 30
depthTukey ........................................................... 31
fncBoxPlot .......................................................... 32
fncDepth ............................................................. 33
fncDepthFM .......................................................... 34
fncDepthMBD .......................................................... 34
fncDepthMedian ..................................................... 35
fncGetBand .......................................................... 36
france ............................................................... 36
FunctionalDepth-class ............................................ 37
getPlot .............................................................. 37
inf.mort ............................................................. 38
internet.users ....................................................... 38
katowice.airpollution ............................................. 39
lsdAddContour ..................................................... 39
LSDepth-class ....................................................... 40
LSDepthContour-class ............................................ 40
lsdGetContour ..................................................... 40
**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**

```r
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**

```r
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
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 $D(x, Z^n), x \in R^d, d \geq 2, Z^n = \{z_1, ..., z_n\} \subset R^d$, $D_\alpha(Z^n)$ denoting $\alpha$ — central region, we can define the asymmetry curve $AC(\alpha) = (\alpha, \|c - 1(\{\bar{z} - med|D_\alpha(Z^n)\})\|) \subset R^2$, 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 convhull in 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

```r
# EXAMPLE 1
library(sn)
x1 <- c(0, 0)
alpha <- c(2, -5)
Omega <- diag(2) * 5

n <- 500
X <- mvrnorm(n, xi, Omega) # normal distribution
```
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.
binningDepth2D

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 \( Z_{i,n-k} = \{(X_{i-n-k}, X_{i-n+1})\}, 1 \leq i \leq n-k \). 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

# EXAMPLE 1
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, 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))
combineDepthCurves  

**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 $L^pdim$ 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

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

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

$$T_{WD}(X^n) = \sum_{i=1}^{n} \frac{d_i X_i}{\sum_{i=1}^{n} d_i},$$

$$DIS(X^n) = \frac{\sum_{i=1}^{n} d_i (X_i - T_{WD}(X^n)) (X_i - T_{WD}(X^n))^T}{\sum_{i=1}^{n} d_i},$$

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

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

# 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)

---

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**
  - logical. 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

```r
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)
```

Description

Class for DDPlot
Slots

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

deeprg2d  Simple deepest regression method.

Description

This function calculates deepest regression estimator for simple regression.

Usage

deeprg2d(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 $RD(\alpha, Z^n) = u \neq 0 \min \{ l : \frac{r(\alpha)}{u^T x_l} < 0, l = 1, ..., n \}$, where $r(\cdot)$ 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 Wegrzynekiewicz 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
depth

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

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

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 $D(x, F) = \frac{1}{1 + Ew(\|x - X\|_p)}$, 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 $Ew(\|x - X\|_p)$ 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
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)
Depth-class  

**Depth**

**Description**

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

**Slots**

- **u** data set.
- **X** reference set.
- **method** depth type.

---

**depthContour**  

**Approximate depth contours**

**Description**

Draws an approximate contours of depth for bivariate data.

**Usage**

```r
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())
```

**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.
- **pdmedian** 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).

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

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

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**

```r
deptheuclid(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, 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).

**Details**

Calculation of Euclidean 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)
deptheuclid(x, x)
```
**depthLocal**

**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 $\beta$,

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

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

$$LD_\beta^x(z, P) : z \rightarrow D(z, P_\beta^x),$$

where $P_\beta^x(\cdot) = P (\cdot | R_\beta^x(P))$ is condition dist. 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, 2)
X1 <- mvrnorm(n = 8500, mu = c(0, 0), Sigma1)
Sigma2 <- matrix(c(10, 0, 0, 2, 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)

---

**Description**

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

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

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

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

depthMah  Mahalanobis Depth

Description

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

```r
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.
- ... currently not supported.

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**

*Depth median*

Description

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

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

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

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

## 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

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

# depthMedian works with object of class Depth
dp <- depth(x)
depthMedian(dp)

---

depthPersp  Perspective plot for depth functions

Description

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

Usage

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 beacuse 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

```r
# 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**
Computation the Projection depth of a point or vectors of points with respect to a multivariate data set.

**Usage**
```r
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 \( X \).

**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)
```
Tukey Depth

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

Usage

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

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

# End(Not run)

# Exact algorithm in 2d
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

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

# 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)
x <- matrix(rnorm(200), ncol = 10)
time <- as.POSIXct(1:ncol(x) * 86400, origin = "1970-01-01")
x_xts <- xts(t(x), 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 ")
**fncDepth**

*Basic function for functional depths*

**Description**

Calculates depth functions.

**Usage**

\[
fncDepth(u, X = NULL, method = "MBD", byrow = NULL, ...)\]

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

```r
## 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(60), ncol = 20)
fncDepth(x, method = "FM", depId = "Mahalanobis")
fncDepth(x, byrow = FALSE)
```

```r
# zoo and xts
library(xts)
data(sample_matrix)
sample.xts <- as.xts(sample_matrix, descr = "my new xts object")
fncDepth(sample.xts)
```
fncDepthFM  

*FM Depth*

**Description**

Computes Frainman-Muniz depth for functional data.

**Usage**

\[
fncDepthFM(u, X, dep1d_params = \text{list(method = "Projection")})
\]

**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**

\[
fncDepthMBD(u, X)
\]

**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)
fncDepthMBD(x)
fncDepthMBD(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**

```r
getPlot(object)
```

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

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

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

Format
A data frame with 654 rows and 4 variables

Source

internet.users | Internet view data

Description
Internet view data

Usage
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
Air pollution in Katowice city by hour.

Usage
data("katowice.airpollution")

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

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

Usage
lsdAddContour(x, cont = NULL, ...)

## S4 method for signature 'LSDepthContour'
lsdAddContour(x, cont = NULL, ...)

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

Examples
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)
```

## S4 method for signature 'LSDepthContour'

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

- **x**: object of class `LSDepthContour`
- **cont**: single numeric — depth of contour to return

Details

Calculations are based on `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)
```

---

**lsdsampledepthcontours**

*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

- **x**: one dimensional vector with sample
- **depth**: depth level for contours
- **lengthmu**: number of points to evaluate depth

Details

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

References

Examples

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

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

```r
lsdSampleMaxDepth(x)
```

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
lsdSampleMaxDepth(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 lsdensity algorithm written by Ch. Muller.

References


Examples

```r
x <- rnorm(100)
lsdSampleMaxDepth(x)
y <- rf(100, 4, 10)
lsdSampleMaxDepth(y)
```
**maesles.imm**  
*Children 1 year old immunized against measles, percentage*

**Description**

Children 1 year old immunized against measles, percentage

**Usage**

```r
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**

```r
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 $X_i'$s depths are more likely to cluster tightly around the center of the combined sample, while $Y_i'$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 rank 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 rank 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 $d_1^n, ..., d_m^n, d_1^Y, ..., d_n^Y$, 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"))
```

```r
# EXAMPLE 2
data(under5.mort)
```
```r
data(inf.mort)
data(maesles.imm)

# 2011
data2011 <- na.omit(cbind(under5.mort[, 22], inf.mort[, 22], maesles.imm[, 22]))

# 1990
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

... graphical parameters passed to plot
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", ...)


plot.LSDepthContour,ANY-method

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

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

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

Description

The function draws a scale curve: measure of dispersion.

Usage

scaleCurve(x, y = NULL, alpha = seq(0, 1, 0.01), name = "X",
        name_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 $D(x, Z^n), x \in R^d, d \geq 2, Z^n = \{z_1, \ldots, z_n\} \subset R^d, D_\alpha(Z^n)$ denoting $\alpha$ — central region, we can define the scale curve $SC(\alpha) = (\alpha, vol(D_\alpha(Z^n))) \subset R^2$, 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

The function 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.
ScaleCurve-class

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 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]
TrimReg2d-class

Description

Class for robust regression methods from depthproc package.
under5.mort

| 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

| 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
Index

*Topic **asymmetry**
  asymmetryCurve, 4
*Topic **contour**
  depthContour, 19
*Topic **curve**
  scaleCurve, 49
*Topic **datasets**
  cracow.airpollution, 11
  france, 36
  inf.mort, 38
  internet.users, 38
  katowice.airpollution, 39
  maesles.imm, 43
  under5.mort, 53
  USLABOUR, 53
*Topic **depth**
  asymmetryCurve, 4
  binningDepth2D, 7
  CovLP, 10
  depth, 17
  depthContour, 19
  depthEuclid, 23
  depthLP, 25
  depthMah, 26
  depthProjection, 30
  depthTukey, 31
  plot,BinnDepth2d,ANY-method, 46
  scaleCurve, 49
*Topic **function**
  asymmetryCurve, 4
  binningDepth2D, 7
  CovLP, 10
  depth, 17
  depthEuclid, 23
  depthLP, 25
  depthMah, 26
  depthProjection, 30
  depthTukey, 31
  plot,BinnDepth2d,ANY-method, 46
  scaleCurve, 49
*Topic **multivariate**
  asymmetryCurve, 4
  binningDepth2D, 7
  CovLP, 10
  depth, 17
  depthEuclid, 23
  depthLP, 25
  depthMah, 26
  depthProjection, 30
  depthTukey, 31
  plot,BinnDepth2d,ANY-method, 46
  scaleCurve, 49
*Topic **nonparametric**
  asymmetryCurve, 4
  binningDepth2D, 7
  CovLP, 10
  depth, 17
  depthEuclid, 23
  depthLP, 25
  depthMah, 26
  depthProjection, 30
  depthTukey, 31
  plot,BinnDepth2d,ANY-method, 46
  scaleCurve, 49
*Topic **robust**
  asymmetryCurve, 4
  binningDepth2D, 7
  CovLP, 10
  depth, 17
  plot,BinnDepth2d,ANY-method, 46
  scaleCurve, 49
*Topic **scale**
  scaleCurve, 49

abline,RbReg-method, 3
as.matrix, 4
as.matrix,DepthCurveList-method
  (as.matrix), 4
asymmetryCurve, 4, 6
<table>
<thead>
<tr>
<th>Method/Function</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>AsymmetryCurve-class</td>
<td>6</td>
</tr>
<tr>
<td>BinnDepth2d-class</td>
<td>6</td>
</tr>
<tr>
<td>binningDepth2D</td>
<td>7</td>
</tr>
<tr>
<td>combineDepthCurves</td>
<td>9</td>
</tr>
<tr>
<td>combineDepthCurves, ANY, ANY, list-method (combineDepthCurves)</td>
<td>9</td>
</tr>
<tr>
<td>combineDepthCurves, DepthCurve, DepthCurve, ANY-method (combineDepthCurves)</td>
<td>9</td>
</tr>
<tr>
<td>combineDepthCurves, DepthCurve, DepthCurveList, ANY-method (combineDepthCurves)</td>
<td>9</td>
</tr>
<tr>
<td>combineDepthCurves, DepthCurveList, DepthCurve, ANY-method (combineDepthCurves)</td>
<td>9</td>
</tr>
<tr>
<td>CovDepthWeighted-class</td>
<td>9</td>
</tr>
<tr>
<td>CovLP</td>
<td>10</td>
</tr>
<tr>
<td>cracow.airpollution</td>
<td>11</td>
</tr>
<tr>
<td>ddmvnorm</td>
<td>12</td>
</tr>
<tr>
<td>ddmvnorm</td>
<td>12</td>
</tr>
<tr>
<td>ddPlot</td>
<td>13</td>
</tr>
<tr>
<td>DDPPlot-class</td>
<td>14</td>
</tr>
<tr>
<td>deepReg2d</td>
<td>15</td>
</tr>
<tr>
<td>DeepReg2d-class</td>
<td>16</td>
</tr>
<tr>
<td>depth</td>
<td>5, 8, 17, 17, 46</td>
</tr>
<tr>
<td>depth-class</td>
<td>15, 19, 21</td>
</tr>
<tr>
<td>depthContour</td>
<td>11, 18, 19, 50</td>
</tr>
<tr>
<td>DepthCurve-class</td>
<td>6, 21, 21, 50</td>
</tr>
<tr>
<td>DepthCurveList-class</td>
<td>21</td>
</tr>
<tr>
<td>depthDensity</td>
<td>22, 23, 46</td>
</tr>
<tr>
<td>DepthDensity-class</td>
<td>23</td>
</tr>
<tr>
<td>depthEuclid</td>
<td>17, 23</td>
</tr>
<tr>
<td>depthLocal</td>
<td>24</td>
</tr>
<tr>
<td>depthLP</td>
<td>25</td>
</tr>
<tr>
<td>depthMah</td>
<td>26</td>
</tr>
<tr>
<td>depthMedian</td>
<td>27</td>
</tr>
<tr>
<td>depthMedian, data.frame-method (depthMedian)</td>
<td>27</td>
</tr>
<tr>
<td>depthMedian, Depth-method (depthMedian)</td>
<td>27</td>
</tr>
<tr>
<td>depthMedian, matrix-method (depthMedian)</td>
<td>27</td>
</tr>
<tr>
<td>depthPersp</td>
<td>11, 18, 20, 28, 50</td>
</tr>
<tr>
<td>depthProjection</td>
<td>30</td>
</tr>
<tr>
<td>depthTukey</td>
<td>31</td>
</tr>
<tr>
<td>fncBoxPlot</td>
<td>32</td>
</tr>
<tr>
<td>fncDepth</td>
<td>33</td>
</tr>
<tr>
<td>fncDepthFM</td>
<td>34</td>
</tr>
<tr>
<td>fncDepthMBD</td>
<td>34</td>
</tr>
<tr>
<td>fncDepthMedian</td>
<td>35</td>
</tr>
<tr>
<td>fncGetBand</td>
<td>36</td>
</tr>
<tr>
<td>france</td>
<td>36</td>
</tr>
<tr>
<td>FunctionalDepth-class</td>
<td>37</td>
</tr>
<tr>
<td>getPlot</td>
<td>37</td>
</tr>
<tr>
<td>getPlot, AsymmetryCurveList-method</td>
<td>37</td>
</tr>
<tr>
<td>getPlot, DDPlot-method (getPlot)</td>
<td>37</td>
</tr>
<tr>
<td>getPlot, ScaleCurveList-method (getPlot)</td>
<td>37</td>
</tr>
<tr>
<td>internet.users</td>
<td>38</td>
</tr>
<tr>
<td>katowice.airpollution</td>
<td>39</td>
</tr>
<tr>
<td>lsdAddContour</td>
<td>39</td>
</tr>
<tr>
<td>lsdAddContour, LSDepthContour-method (lsdAddContour)</td>
<td>39</td>
</tr>
<tr>
<td>LSDepth-class</td>
<td>40</td>
</tr>
<tr>
<td>LSDepthContour-class</td>
<td>40</td>
</tr>
<tr>
<td>lsdGetContour</td>
<td>40</td>
</tr>
<tr>
<td>lsdGetContour, LSDepthContour-method (lsdGetContour)</td>
<td>40</td>
</tr>
<tr>
<td>lsdSampleDepthContours</td>
<td>41, 47</td>
</tr>
<tr>
<td>lsdSampleMaxDepth</td>
<td>42</td>
</tr>
<tr>
<td>maesles.imm</td>
<td>43</td>
</tr>
<tr>
<td>mWilcoxonTest</td>
<td>43</td>
</tr>
<tr>
<td>plot</td>
<td>45</td>
</tr>
<tr>
<td>plot, BinnDepth2d, ANY-method</td>
<td>46</td>
</tr>
<tr>
<td>plot, DDPPlot, ANY-method (plot)</td>
<td>45</td>
</tr>
<tr>
<td>plot, DepthCurve, ANY-method (plot)</td>
<td>45</td>
</tr>
<tr>
<td>plot, DepthCurveList, ANY-method (plot)</td>
<td>45</td>
</tr>
<tr>
<td>plot, DepthDensity, ANY-method</td>
<td>46</td>
</tr>
<tr>
<td>plot, LSDepthContour, ANY-method</td>
<td>47</td>
</tr>
<tr>
<td>RobReg-class</td>
<td>48</td>
</tr>
<tr>
<td>runifsphere</td>
<td>48</td>
</tr>
<tr>
<td>scaleCurve</td>
<td>5, 49, 50</td>
</tr>
<tr>
<td>ScaleCurve-class</td>
<td>50</td>
</tr>
<tr>
<td>trimProjReg2d</td>
<td>51</td>
</tr>
<tr>
<td>TrimReg2d-class</td>
<td>52</td>
</tr>
<tr>
<td>under5.mort</td>
<td>53</td>
</tr>
<tr>
<td>USLABOUR</td>
<td>53</td>
</tr>
</tbody>
</table>