# Package ‘rrcov’

**Version** 1.4-3  
**Date** 2016-09-03  
**Title** Scalable Robust Estimators with High Breakdown Point  
**Author** Valentin Todorov <valentin.todorov@chello.at>  
**Description** Robust Location and Scatter Estimation and Robust Multivariate Analysis with High Breakdown Point.  
**Maintainer** Valentin Todorov <valentin.todorov@chello.at>  
**Depends** R (>= 2.10), robustbase (>= 0.92-1), methods  
**Imports** stats, stats4, mvtnorm, lattice, cluster, pcaPP  
**Suggests** grid, mclust, MASS, ellipse  
**LazyLoad** yes  
**License** GPL (>= 2)  
**Repository** CRAN  
**NeedsCompilation** yes  
**Date/Publication** 2016-09-06 08:03:44

## R topics documented:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appalachia</td>
<td>3</td>
</tr>
<tr>
<td>biplot-methods</td>
<td>5</td>
</tr>
<tr>
<td>bus</td>
<td>6</td>
</tr>
<tr>
<td>bushmiss</td>
<td>8</td>
</tr>
<tr>
<td>Cascades</td>
<td>10</td>
</tr>
<tr>
<td>Cov-class</td>
<td>11</td>
</tr>
<tr>
<td>CovClassic</td>
<td>13</td>
</tr>
<tr>
<td>CovClassic-class</td>
<td>14</td>
</tr>
<tr>
<td>CovControl-class</td>
<td>15</td>
</tr>
<tr>
<td>CovControlMcd</td>
<td>16</td>
</tr>
<tr>
<td>CovControlMcd-class</td>
<td>17</td>
</tr>
<tr>
<td>CovControlMest</td>
<td>18</td>
</tr>
<tr>
<td>CovControlMest-class</td>
<td>19</td>
</tr>
</tbody>
</table>
R topics documented:

- CovControlMMest
- CovControlMMest-class
- CovControlMve
- CovControlMve-class
- CovControlOgk
- CovControlOgk-class
- CovControlSde
- CovControlSde-class
- CovControlSest
- CovControlSest-class
- CovMcd
- CovMcd-class
- CovMest
- covMest
- CovMest-class
- CovMMest
- CovMMest-class
- CovMve
- CovMve-class
- CovOgk
- CovOgk-class
- CovRobust
- CovRobust-class
- CovSde
- CovSde-class
- CovSest
- CovSest-class
- fish
- getCenter-methods
- getLoadings-methods
- hemophilia
- isSingular-methods
- Lda-class
- LdaClassic
- LdaClassic-class
- LdaPP
- LdaPP-class
- LdaRobust-class
- Linda
- Linda-class
- lmom32
- lmom33
- maryo
- OsloTransect
- Pca-class
- pca.distances
- pca.scoreplot
- PcaClassic

Page dimensions: 612.0x792.0
Appalachia

Annual maximum streamflow in central Appalachia

Description

The data on annual maximum streamflow at 104 gaging stations in the central Appalachia region of the United States contains the sample L-moments ratios (L-CV, L-skewness and L-kurtosis) as used by Hosking and Wallis (1997) to illustrate regional frequency analysis (RFA).
Usage
data(Appalachia)

Format
A data frame with 104 observations on the following 3 variables:

L-CV  L-coefficient of variation
L-skewness  L-coefficient of skewness
L-kurtosis  L-coefficient of kurtosis

Details
The sample L-moment ratios (L-CV, L-skewness and L-kurtosis) of a site are regarded as a point in three dimensional space.

Source

References

Examples
data(Appalachia)

# plot a matrix of scatterplots
pairs(Appalachia,
     main="Appalachia data set",
     pch=21,
     bg=c("red", "green3", "blue"))

mcd <- CovMcd(Appalachia)
mcd
plot(mcd, which="dist", class=TRUE)
plot(mcd, which="dd", class=TRUE)

## identify the discordant sites using robust distances and compare
## to the classical ones
mcd <- CovMcd(Appalachia)
rout <- sqrt(getDistance(mcd))
cov <- CovClassic(Appalachia)
cd <- sqrt(getDistance(cov))
r.out <- which(rout > sqrt(qchisq(0.975,3)))
c.out <- which(cd > sqrt(qchisq(0.975,3)))
biplot-methods

Biplot for Principal Components (objects of class 'Pca')

Description

Produces a biplot from an object (derived from) Pca-class.

Usage

```r
## S4 method for signature 'Pca'
biplot(x, choices=1L:2L, scale=1, ...)
```

Arguments

- `x`: an object of class (derived from) "Pca".
- `choices`: length 2 vector specifying the components to plot. Only the default is a biplot in the strict sense.
- `scale`: The variables are scaled by \( \lambda^\text{scale} \) and the observations are scaled by \( \lambda^\text{(1-scale)} \) where \( \lambda \) are the singular values as computed by the Principal Components function. Normally \( 0 \leq \text{scale} \leq 1 \), and a warning will be issued if the specified scale is outside this range.
- `...`: optional arguments to be passed to the internal graphical functions.

Side Effects

A plot is produced on the current graphics device.

Methods

- `biplot` signature(x = Pca): Plot a biplot, i.e. represent both the observations and variables of a matrix of multivariate data on the same plot. See also `biplot.princomp`.

References


See Also

Pca-class, PcaClassic, PcaRobust-class.

Examples

```r
require(graphics)
biplot(PcaClassic(USArrests, k=2))
```
Description

The data set bus (Hettich and Bay, 1999) corresponds to a study in automatic vehicle recognition (see Maronna et al. 2006, page 213, Example 6.3)). This data set from the Turing Institute, Glasgow, Scotland, contains measures of shape features extracted from vehicle silhouettes. The images were acquired by a camera looking downward at the model vehicle from a fixed angle of elevation. Each of the 218 rows corresponds to a view of a bus silhouette, and contains 18 attributes of the image.

Usage

data(bus)

Format

A data frame with 218 observations on the following 18 variables:

V1  compactness
V2  circularity
V3  distance circularity
V4  radius ratio
V5  principal axis aspect ratio
V6  maximum length aspect ratio
V7  scatter ratio
V8  elongatedness
V9  principal axis rectangularity
V10 maximum length rectangularity
V11 scaled variance along major axis
V12 scaled variance along minor axis
V13 scaled radius of gyration
V14 skewness about major axis
V15 skewness about minor axis
V16 kurtosis about minor axis
V17 kurtosis about major axis
V18 hollows ratio

Source

Hettich, S. and Bay, S.D. (1999), The UCI KDD Archive, Irvine, CA:University of California, Department of Information and Computer Science,

'http://kdd.ics.uci.edu'
References


Examples

```r
## Reproduce Table 6.3 from Maronna et al. (2006), page 213
data(bus)
bus <- as.matrix(bus)

## calculate MADN for each variable
xmad <- apply(bus, 2, mad)
cat("\nMin, Max of MADN: ", min(xmad), max(xmad), "\n")

## MADN vary between 0 (for variable 9) and 34. Therefore exclude
## variable 9 and divide the remaining variables by their MADNs.
bus1 <- bus[, -9]
madbus <- apply(bus1, 2, mad)
bus2 <- sweep(bus1, 2, madbus, "/", check.margin = FALSE)

## Compute classical and robust PCA (Spherical/Locantore, Hubert, MCD and OGK)
pca <- PCAclassic(bus2)
rpca <- PCAlocantore(bus2)
pcaHubert <- PCAHubert(bus2, k=17, kmax=17, mcd=FALSE)
pcamcd <- PcaCov(bus2, cov.control=CovControlMcd())
pcaogk <- PcaCov(bus2, cov.control=CovControlOgk())

ev <- getEigenvalues(pca)
evrob <- getEigenvalues(rpca)
evhub <- getEigenvalues(pcaHubert)
evMCD <- getEigenvalues(pcamcd)
evogk <- getEigenvalues(pcaogk)

uvar <- matrix(nrow=6, ncol=6)
svar <- sum(ev)
svarrob <- sum(evrob)
svarhub <- sum(evhub)
svarMCD <- sum(evMCD)
svarogk <- sum(evogk)
for(i in 1:6){
  uvar[i,1] <- i
  uvar[i,2] <- round((svar - sum(ev[1:i]))/svar, 3)
  uvar[i,3] <- round((svarrob - sum(evrob[1:i]))/svarrob, 3)
  uvar[i,4] <- round((svarhub - sum(evhub[1:i]))/svarhub, 3)
  uvar[i,5] <- round((svarMCD - sum(evMCD[1:i]))/svarMCD, 3)
  uvar[i,6] <- round((svarogk - sum(evogk[1:i]))/svarogk, 3)
}
uvar <- as.data.frame(uvar)
names(uvar) <- c("q", "Classical", "Spherical", "Hubert", "MCD", "OGK")
cat("\nBus data: proportion of unexplained variability for q components\n")
print(uvar)
```
## Reproduce Table 6.4 from Maronna et al. (2006), page 214

## Compute classical and robust PCA extracting only the first 3 components
## and take the squared orthogonal distances to the 3-dimensional hyperplane

```r
pca3 <- PcaClassic(bus2, k=3)  # classical
r pca3 <- PcaLocantore(bus2, k=3)  # spherical (Locantore, 1999)
hpca3 <- PcaHubert(bus2, k=3)  # Hubert
dist <- pca3@od^2
rdist <- rpca3@od^2
hdist <- hpca3@od^2
```

## calculate the quantiles of the distances to the 3-dimensional hyperplane

```r
qclass <- round(quantile(dist, probs = seq(0, 1, 0.1)[-c(1,11)]), 1)
qspc <- round(quantile(rdist, probs = seq(0, 1, 0.1)[-c(1,11)]), 1)
qhbert <- round(quantile(hdist, probs = seq(0, 1, 0.1)[-c(1,11)]), 1)
qq <- cbind(rbind(qclass, qspc, qhubert), round(c(max(dist), max(rdist), max(hdist)), 0))
colnames(qq)[10] <- "Max"
rownames(qq) <- c("Classical", "Spherical", "Hubert")
cat("\nBus data: quantiles of distances to hiperplane\n")
print(qq)
```

## Reproduce Fig 6.1 from Maronna et al. (2006), page 214

```r
plot(sort(log(dist)), sort(log(rdist)), xlab="classical", ylab="robust")
lines(sort(log(dist)), sort(log(dist)))
```

---

### bushmiss

**Campbell Bushfire Data with added missing data items**

#### Description

This data set is based on the bushfire data set which was used by Campbell (1984) to locate bushfire scars - see `bushfire` in package `robustbase`. The original dataset contains satellite measurements on five frequency bands, corresponding to each of 38 pixels.

#### Usage

```r
data(bushmiss)
```

#### Format

A data frame with 190 observations on 6 variables.
The original data set consists of 38 observations in 5 variables. Based on it four new data sets are created in which some of the data items are replaced by missing values with a simple "missing completely at random" mechanism. For this purpose independent Bernoulli trials are realized for each data item with a probability of success 0.1, 0.2, 0.3, 0.4, where success means that the corresponding item is set to missing. The obtained five data sets, including the original one (each with probability of a data item to be missing equal to 0, 0.1, 0.2, 0.3 and 0.4 which is reflected in the new variable `mprob`) are merged. (See also Beguin and Hulliger (2004).)

**Source**


**Examples**

```r
## The following code will result in exactly the same output
## as the one obtained from the original data set
data(bushmiss)
bf <- bushmiss[bushmiss$mprob==0:1:5]
plot(bf)
covMcd(bf)

## Not run:
## This is the code with which the missing data were created:
##
## Creates a data set with missing values (for testing purposes)
## from a complete data set 'x'. The probability of
## each item being missing is 'pr' (Bernoulli trials).
##
## getmiss <- function(x, pr=0.1)
## {
##   n <- nrow(x)
p <- ncol(x)
done <- FALSE
iter <- 0
while(iter <= 50){
   bt <- rbinom(n*p, 1, pr)
   btmat <- matrix(bt, nrow=n)
   btmiss <- ifelse(btmat==1, NA, 0)
   y <- x+btmiss
   if(length(which(rowSums(nanmap(y)) == p)) == 0)
      return(y)
iter <- iter + 1
}
y
```

Cascades

## Cascades

### Description

The data on annual precipitation totals for the North Cascades region contains the sample L-moments ratios (L-CV, L-skewness and L-kurtosis) for 19 sites as used by Hosking and Wallis (1997), page 53, Table 3.4, to illustrate screening tools for regional frequency analysis (RFA).

### Usage

data(Cascades)

### Format

A data frame with 19 observations on the following 3 variables.

- `lMCV` L-coefficient of variation
- `lMSkewness` L-coefficient of skewness
- `lMKurtosis` L-coefficient of kurtosis

### Details

The sample L-moment ratios (L-CV, L-skewness and L-kurtosis) of a site are regarded as a point in three dimensional space.

### Source


### References

Examples

```r
# plot a matrix of scatterplots
data(Cascades)
pairs(Cascades,
    main="Cascades data set",
    pch=21,
    bg=c("red", "green3", "blue"))

mcd<-CovMcd(Cascades)
mcd
plot(mcd, which="dist", class=TRUE)
plot(mcd, which="dd", class=TRUE)

## identify the discordant sites using robust distances and compare
## to the classical ones
rd <- sqrt(getDistance(mcd))
ccov <- CovClassic(Cascades)
cd <- sqrt(getDistance(ccov))
r.out <- which(rd > sqrt(qchisq(0.975,3)))
c.out <- which(cd > sqrt(qchisq(0.975,3)))
cat("Robust: ", length(r.out), " outliers: ", r.out,"\n")
cat("Classical: ", length(c.out), " outliers: ", c.out,"\n")
```

---

**Description**

The class `Cov` represents an estimate of the multivariate location and scatter of a data set. The objects of class `Cov` contain the classical estimates and serve as base for deriving other estimates, i.e. different types of robust estimates.

**Objects from the Class**

Objects can be created by calls of the form `new("Cov", ...), but the usual way of creating `Cov` objects is a call to the function `Cov` which serves as a constructor.

**Slots**

- `call`: Object of class "language"
- `cov`: covariance matrix
- `center`: location
- `n.obs`: number of observations used for the computation of the estimates
- `mah`: mahalanobis distances
- `det`: determinant
flag: flags (FALSE if suspected an outlier)

method: a character string describing the method used to compute the estimate: "Classic"

singularity: a list with singularity information for the covariance matrix (or NULL of not singular)

x: data

Methods

getCenter signature(obj = "Cov"): location vector

getCov signature(obj = "Cov"): covariance matrix

getCorr signature(obj = "Cov"): correlation matrix

getData signature(obj = "Cov"): data frame

getDistance signature(obj = "Cov"): distances

getEvals signature(obj = "Cov"): Computes and returns the eigenvalues of the covariance matrix

getDet signature(obj = "Cov"): Computes and returns the determinant of the covariance matrix (or 0 if the covariance matrix is singular)

getShape signature(obj = "Cov"): Computes and returns the shape matrix corresponding to the covariance matrix (i.e. the covariance matrix scaled to have determinant =1)

getFlag signature(obj = "Cov"): Flags observations as outliers if the corresponding mahalanobis distance is larger then qchisq(prob, p) where prob defaults to 0.975.

isClassic signature(obj = "Cov"): returns TRUE by default. If necessary, the robust classes will override

plot signature(x = "Cov"): plot the object

show signature(object = "Cov"): display the object

summary signature(object = "Cov"): calculate summary information

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


Examples

showClass("Cov")
Description

Computes the classical estimates of multivariate location and scatter. Returns an S4 class CovClassic with the estimated center, cov, Mahalanobis distances and weights based on these distances.

Usage

CovClassic(x, unbiased=TRUE)
Cov(x, unbiased=TRUE)

Arguments

x a matrix or data frame. As usual, rows are observations and columns are variables.
unbiased whether to return the unbiased estimate of the covariance matrix. Default is unbiased = TRUE

Value

An object of class "CovClassic".

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

Cov-class, CovClassic-class

Examples

data(hbk)
hbk.x <- data.matrix(hbk[, 1:3])
cv <- CovClassic(hbk.x)
cv
summary(cv)
plot(cv)
Class "CovClassic" - classical estimates of multivariate location and scatter

Description

The class CovClassic represents an estimate of the multivariate location and scatter of a data set. The objects of class CovClassic contain the classical estimates.

Objects from the Class

Objects can be created by calls of the form `new("CovClassic", ...)`, but the usual way of creating CovClassic objects is a call to the function `covclassic` which serves as a constructor.

Slots

call: Object of class "language"
cov: covariance matrix
center: location
n.obs: number of observations used for the computation of the estimates
mah: mahalanobis distances
method: a character string describing the method used to compute the estimate: "Classic"
singularity: a list with singularity information for the covariance matrix (or NULL of not singular)
x: data

Methods

`getCenter` signature(obj = "CovClassic"): location vector
`getCov` signature(obj = "CovClassic"): covariance matrix
`getCorr` signature(obj = "CovClassic"): correlation matrix
`getData` signature(obj = "CovClassic"): data frame
`getDistance` signature(obj = "CovClassic"): distances
`getEvals` signature(obj = "CovClassic"): Computes and returns the eigenvalues of the covariance matrix
`plot` signature(x = "CovClassic"): plot the object
`show` signature(object = "CovClassic"): display the object
`summary` signature(object = "CovClassic"): calculate summary information

Author(s)

Valentin Todorov <valentin.todorov@chello.at>
References


Examples

```r
data(hbk)
hbk.x <- data.matrix(hbk[, 1:3])
cv <- CovClassic(hbk.x)
cv
summary(cv)
plot(cv)
```

Description

The class "CovControl" is a VIRTUAL base control class for the derived classes representing the control parameters for the different robust methods.

Arguments

- `trace` whether to print intermediate results. Default is `trace = FALSE`
- `tolSolve` numeric tolerance to be used for inversion (`solve`) of the covariance matrix in `mahalanobis`.

Objects from the Class

A virtual Class: No objects may be created from it.

Methods

No methods defined with class "CovControl" in the signature.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References

CovControlMcd

Constructor function for objects of class "CovControlMcd"

Description

This function will create a control object CovControlMcd containing the control parameters for CovMcd

Usage

CovControlMcd(alpha = 0.5, nsamp = 500, scalefn=NULL, maxcsteps=200,
seed = NULL, trace= FALSE, use.correction = TRUE)

Arguments

alpha numeric parameter controlling the size of the subsets over which the determinant is minimized, i.e., alpha*n observations are used for computing the determinant. Allowed values are between 0.5 and 1 and the default is 0.5.

nsamp number of subsets used for initial estimates or "best", "exact" or "deterministic". Default is nsamp = 500. For nsamp="best" exhaustive enumeration is done, as long as the number of trials does not exceed 5000. For "exact", exhaustive enumeration will be attempted however many samples are needed. In this case a warning message will be displayed saying that the computation can take a very long time.

For "deterministic", the deterministic MCD is computed; as proposed by Hubert et al. (2012) it starts from the h most central observations of six (deterministic) estimators.

scalefn function to compute a robust scale estimate or character string specifying a rule determining such a function, see rrcov.control.

maxcsteps maximal number of concentration steps in the deterministic MCD; should not be reached.

seed starting value for random generator. Default is seed = NULL
	race whether to print intermediate results. Default is trace = FALSE

use.correction whether to use finite sample correction factors. Default is use.correction=TRUE

Value

A CovControlMcd object

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References

Examples

```r
## the following two statements are equivalent
ctrl1 <- new("CovControlMcd", alpha=0.75)
ctrl2 <- CovControlMcd(alpha=0.75)

data(hbk)
CovMcd(hbk, control=ctrl1)
```
Methods

`restimate` signature(obj = "CovControlMcd"): the generic function `restimate` allows the different methods for robust estimation to be used polymorphically - this function will call `CovMcd` passing it the control object and will return the obtained `CovRobust` object.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


Examples

```r
## the following two statements are equivalent
ctrl1 <- new("CovControlMcd", alpha=0.75)
ctrl2 <- CovControlMcd(alpha=0.75)

data(hbk)
CovMcd(hbk, control=ctrl1)
```

---

**CovControlMest**

Constructor function for objects of class "CovControlMest"

Description

This function will create a control object `CovControlMest` containing the control parameters for `CovMest`

Usage

`CovControlMest(r = 0.45, arp = 0.05, eps = 0.001, maxiter = 120)`

Arguments

- `r`: a numeric value specifying the required breakdown point. Allowed values are between \((n - p)/(2 \times n)\) and 1 and the default is 0.45.
- `arp`: a numeric value specifying the asymptotic rejection point, i.e. the fraction of points receiving zero weight (see Rocke (1996)). Default is 0.05.
- `eps`: a numeric value specifying the relative precision of the solution of the M-estimate. Defaults to 1e-3.
- `maxiter`: maximum number of iterations allowed in the computation of the M-estimate. Defaults to 120.
Value

A `CovControlMest` object

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


Examples

```r
## the following two statements are equivalent
ctrl1 <- new("CovControlMest", r=0.4)
ctrl2 <- CovControlMest(r=0.4)

data(hbk)
CovMest(hbk, control=ctrl1)
```

Description

This class extends the `CovControl` class and contains the control parameters for CovMest

Objects from the Class

Objects can be created by calls of the form `new("CovControlMest", ...)` or by calling the constructor-function `CovControlMest`.

Slots

- `r`: a numeric value specifying the required breakdown point. Allowed values are between \((n - p)/(2 \times n)\) and 1 and the default is 0.45
- `arp`: a numeric value specifying the asymptotic rejection point, i.e. the fraction of points receiving zero weight (see Rocke (1996)). Default is 0.05
- `eps`: a numeric value specifying the relative precision of the solution of the M-estimate. Defaults to 1e-3
- `maxiter`: maximum number of iterations allowed in the computation of the M-estimate. Defaults to 120
- `trace`, `tolSolve`: from the "CovControl" class.
Extends

Class "CovControl", directly.

Methods

restimate signature(obj = "CovControlMMest"): the generic function restimate allows the different methods for robust estimation to be used polymorphically - this function will call CovMest passing it the control object and will return the obtained CovRobust object

Author(s)

Valentin Todorov <valentin.todorov@hellow.at>

References


Examples

## the following two statements are equivalent
ctrl1 <- new("CovControlMMest", r=0.4)
crl2 <- CovControlMMest(r=0.4)

data(hbk)
CovMest(hbk, control=ctrl1)

---

CovControlMMest

Constructor function for objects of class "CovControlMMest"

Description

This function will create a control object CovControlMMest containing the control parameters for CovMMest

Usage

CovControlMMest(bdp = 0.5, eff=0.95, maxiter = 50, sest=CovControlSest(),
trace = FALSE, tolsolve = 1e-7)

Arguments

bdp a numeric value specifying the required breakdown point. Allowed values are between 0.5 and 1 and the default is 0.5

eff a numeric value specifying the required efficiency for the MM estimates. Default is eff=0.95.
**CovControlMMest-class**

- **sest**: an `CovControlSest` object containing control parameters for the initial S-estimate.
- **maxiter**: maximum number of iterations allowed in the computation of the MM-estimate. Defaults to 150.
- **trace**: whether to print intermediate results. Default is `trace = FALSE`.
- **tolSolve**: numeric tolerance to be used as a convergence tolerance for the MM-iteration.

**Value**

A `CovControlSest` object.

**Author(s)**

Valentin Todorov <valentin.todorov@chello.at>

**References**


**Examples**

```r
## the following two statements are equivalent
ctrl1 <- new("CovControlMMest", bdp=0.25)
ctrl2 <- CovControlMMest(bdp=0.25)

data(hbk)
CovMMest(hbk, control=ctrl1)
```

---

**Description**

This class extends the `CovControl` class and contains the control parameters for CovMMest.

**Objects from the Class**

Objects can be created by calls of the form `new("CovControlMMest", ...)` or by calling the constructor-function `CovControlMMest`. 
Slots

bdp a numeric value specifying the required breakdown point. Allowed values are between 0.5 and 1 and the default is bdp=0.5.

eff a numeric value specifying the required efficiency for the MM estimates. Default is eff=0.95.

sest an CovControlSest object containing control parameters for the initial S-estimate.

maxiter maximum number of iterations allowed in the computation of the MM-estimate. Default is maxiter=50.

trace, tolSolve: from the "CovControl" class. tolSolve is used as a convergence tolerance for the MM-iteration.

Extends

Class "CovControl", directly.

Methods

restimate signature(obj = "CovControlMMest"): the generic function restimate allows the different methods for robust estimation to be used polymorphically - this function will call CovMMest passing it the control object and will return the obtained CovRobust object.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


Examples

# the following two statements are equivalent
ctrl11 <- new("CovControlMMest", bdp=0.25)
ctrl12 <- CovControlMMest(bdp=0.25)

data(hbk)
CovMMest(hbk, control=ctrl11)
Description
This function will create a control object CovControlMve containing the control parameters for CovMve.

Usage

covcontrolmve(\alpha = 0.5, \text{nsamp} = 500, \text{seed} = \text{NULL}, \text{trace} = \text{FALSE})

Arguments

- \text{alpha} numeric parameter controlling the size of the subsets over which the determinant is minimized, i.e., \alpha n observations are used for computing the determinant. Allowed values are between 0.5 and 1 and the default is 0.5.
- \text{nsamp} number of subsets used for initial estimates or "best" or "exact". Default is \text{nsamp} = 500. For \text{nsamp}="best" exhaustive enumeration is done, as long as the number of trials does not exceed 5000. For "exact", exhaustive enumeration will be attempted however many samples are needed. In this case a warning message will be displayed saying that the computation can take a very long time.
- \text{seed} starting value for random generator. Default is \text{seed} = \text{NULL}
- \text{trace} whether to print intermediate results. Default is \text{trace} = \text{FALSE}

Value
A CovControlMve object

Author(s)
Valentin Todorov <valentin.todorov@chello.at>

References

Examples

```r
## the following two statements are equivalent
ctrl1 <- new("CovControlMve", alpha=0.75)
ctrl2 <- CovControlMve(alpha=0.75)

data(hbk)
CovMve(hbk, control=ctrl1)
```
Description

This class extends the CovControl class and contains the control parameters for "CovMve"

Objects from the Class

Objects can be created by calls of the form new("CovControlMve", ...) or by calling the constructor-function CovControlMve.

Slots

alpha: numeric parameter controlling the size of the subsets over which the determinant is minimized, i.e., alpha*n observations are used for computing the determinant. Allowed values are between 0.5 and 1 and the default is 0.5.

nsamp: number of subsets used for initial estimates or "best" or "exact". Default is nsamp = 500. For nsamp="best" exhaustive enumeration is done, as long as the number of trials does not exceed 5000. For "exact", exhaustive enumeration will be attempted however many samples are needed. In this case a warning message will be displayed saying that the computation can take a very long time.

seed: starting value for random generator. Default is seed = NULL

trace, tolsolve: from the "CovControl" class.

Extends

Class "CovControl", directly.

Methods

restimate signature(obj = "CovControlMve"): the generic function restimate allows the different methods for robust estimation to be used polymorphically - this function will call CovMve passing it the control object and will return the obtained CovRobust object

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References

Examples

```r
## the following two statements are equivalent
ctrl1 <- new("CovControlMve", alpha=0.75)
ctrl2 <- CovControlMve(alpha=0.75)

data(hbk)
CovMve(hbk, control=ctrl1)
```

Description

This function will create a control object `CovControlOgk` containing the control parameters for `CovOgk`.

Usage

```r
CovControlOgk(niter = 2, beta = 0.9, mrob = NULL,
vrob = .vrobGK, smrob = "scaleTau2", svrob = "gk")
```

Arguments

- `niter` number of iterations, usually 1 or 2 since iterations beyond the second do not lead to improvement.
- `beta` coverage parameter for the final reweighted estimate.
- `mrob` function for computing the robust univariate location and dispersion - one could use the tau scale defined in Yohai and Zamar (1998), see `scaleTau2`. The C version of this function defined by `smrob` is the default.
- `vrob` function for computing robust estimate of covariance between two random vectors - one could use the function proposed by Gnanadesikan and Kettenring (1972), see `covGK()`. The C version of this function defined by `svrob` is the default.
- `smrob` a string indicating the name of the function for computing the robust univariate location and dispersion - defaults to `scaleTau2` - the scale tau function defined in Yohai and Zamar (1998).
- `svrob` a string indicating the name of the function for computing robust estimate of covariance between two random vectors - defaults `gk`, the one proposed by Gnanadesikan and Kettenring (1972).

Details

If the user does not specify a scale and covariance function to be used in the computations or specifies one by using the arguments `smrob` and `svrob` (i.e. the names of the functions as strings), a native code written in C will be called which is by far faster than the R version.

If the arguments `mrob` and `vrob` are not NULL, the specified functions will be used via the pure R implementation of the algorithm. This could be quite slow.
Value

A CovControlOgk object

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


Examples

```r
## the following two statements are equivalent
ctrl1 <- new("CovControlOgk", beta=0.95)
ctrl2 <- CovControlOgk(beta=0.95)

data(hbk)
CovOgk(hbk, control=ctrl1)
```

Description

This class extends the CovControl class and contains the control parameters for "CovOgk"

Objects from the Class

Objects can be created by calls of the form new("CovControlOgk", ...) or by calling the constructor-function CovControlOgk.

Slots

- **niter**: number of iterations, usually 1 or 2 since iterations beyond the second do not lead to improvement.
- **beta**: coverage parameter for the final reweighted estimate
- **mrob**: function for computing the robust univariate location and dispersion - defaults to the tau scale defined in Yohai and Zamar (1998)
**CovControlSde**

- **vrob** function for computing robust estimate of covariance between two random vectors - defaults the one proposed by Gnanadesikan and Kettenring (1972)

- **smrob** A string indicating the name of the function for computing the robust univariate location and dispersion - defaults to scaleTau2 - the scale 'tau' function defined in Yohai and Zamar (1998)

- **svrob** A string indicating the name of the function for computing robust estimate of covariance between two random vectors - defaults to gk, the one proposed by Gnanadesikan and Kettenring (1972).

- **trace, tolSolve**: from the "CovControl" class.

**Extends**

Class "CovControl", directly.

**Methods**

- **restimate** signature(obj = "CovControl0gk"): the generic function restimate allows the different methods for robust estimation to be used polymorphically - this function will call CovOgk passing it the control object and will return the obtained CovRobust object

**Author(s)**

Valentin Todorov <valentin.todorov@chello.at>

**References**


**Examples**

```r
## the following two statements are equivalent
ctrl1 <- new("CovControl0gk", beta=0.95)
ctrl2 <- CovControl0gk(beta=0.95)

data(hbk)
CovOgk(hbk, control=ctrl1)
```

---

**CovControlSde**

*Constructor function for objects of class "CovControlSde"*

**Description**

This function will create a control object CovControlSde containing the control parameters for CovSde
Usage

CovControlSde(nsamp = 0, maxres = 0, tune = 0.95, eps = 0.5, prob = 0.99,
seed = NULL, trace = FALSE, tolSolve = 1e-14)

Arguments

nsamp a positive integer giving the number of resamples required; nsamp may not be reached if too many of the p-subsamples, chosen out of the observed vectors, are in a hyperplane. If nsamp = 0 all possible subsamples are taken. If nsamp is omitted, it is calculated to provide a breakdown point of eps with probability prob.

maxres a positive integer specifying the maximum number of resamples to be performed including those that are discarded due to linearly dependent subsamples. If maxres is omitted it will be set to 2 times nsamp.

tune a numeric value between 0 and 1 giving the fraction of the data to receive non-zero weight. Defaults to 0.95.

prob a numeric value between 0 and 1 specifying the probability of high breakdown point; used to compute nsamp when nsamp is omitted. Defaults to 0.99.

eps a numeric value between 0 and 0.5 specifying the breakdown point; used to compute nsamp when nresamp is omitted. Defaults to 0.5.

seed starting value for random generator. Default is seed = NULL.

trace whether to print intermediate results. Default is trace = FALSE.

tolSolve numeric tolerance to be used for inversion (solve) of the covariance matrix in mahalanobis.

Value

A CovControlSde object.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


Examples

## the following two statements are equivalent
ctrl1 <- new("CovControlSde", nsamp=2000)
ctrl2 <- CovControlSde(nsamp=2000)

data(hbk)
CovSde(hbk, control=ctrl1)
Description

This class extends the CovControl class and contains the control parameters for CovSde.

Objects from the Class

Objects can be created by calls of the form `new("CovControlSde", ...)` or by calling the constructor-function `covControlSde`.

Slots

- `nsamp`: a positive integer giving the number of resamples required.
- `maxres`: a positive integer specifying the maximum number of resamples to be performed including those that are discarded due to linearly dependent subsamples.
- `tune`: a numeric value between 0 and 1 giving the fraction of the data to receive non-zero weight. Default is `tune = 0.95`.
- `prob`: a numeric value between 0 and 1 specifying the probability of high breakdown point; used to compute `nsamp` when `nsamp` is omitted. Default is `prob = 0.99`.
- `eps`: a numeric value between 0 and 0.5 specifying the breakdown point; used to compute `nsamp` when `nresamp` is omitted. Default is `eps = 0.5`.
- `seed`: starting value for random generator. Default is `seed = NULL`.
- `trace`, `tolSolve`: from the "CovControl" class.

Extends

Class "CovControl", directly.

Methods

- `restimate` signature(obj = "CovControlSde"): ...

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References

Examples

```r
## the following two statements are equivalent
ctrl1 <- new("CovControlSde", nsamp=2000)
ctrl2 <- CovControlSde(nsamp=2000)

data(hbk)
CovSde(hbk, control=ctrl1)
```

---

**CovControlSest**  
Constructor function for objects of class "CovControlSest"

---

**Description**

This function will create a control object CovControlSest containing the control parameters for CovSest

**Usage**

```r
CovControlSest(bdp = 0.5, arp = 0.1, eps = 1e-5, maxiter = 120,
nsamp = 500, seed = NULL, trace = FALSE, tolsolve = 1e-14, method = "sfast")
```

**Arguments**

- **bdp**: a numeric value specifying the required breakdown point. Allowed values are between \((n - p)/(2 \times n)\) and 1 and the default is 0.45
- **arp**: a numeric value specifying the asymptotic rejection point (for the Rocke type S estimates), i.e. the fraction of points receiving zero weight (see Rocke (1996)). Default is 0.1
- **eps**: a numeric value specifying the relative precision of the solution of the S-estimate (bisquare and Rocke type). Default to 1e-5.
- **maxiter**: maximum number of iterations allowed in the computation of the S-estimate (bisquare and Rocke type). Defaults to 120.
- **nsamp**: the number of random subsets considered. Default is nsamp = 500.
- **seed**: starting value for random generator. Default is seed = NULL.
- **trace**: whether to print intermediate results. Default is trace = FALSE.
- **tolsolve**: numeric tolerance to be used for inversion (solve) of the covariance matrix in `mahalanobis`.
- **method**: Which algorithm to use: 'sfast'=FAST-S or 'surreal'=SURREAL

**Value**

A CovControlSest object.

**Author(s)**

Valentin Todorov <valentin.todorov@chello.at>
CovControlSest-class

References


Examples

```r
## the following two statements are equivalent
ctrl1 <- new("CovControlSest", bdp=0.4)
ctrl2 <- CovControlSest(bdp=0.4)

data(hbk)
CovSest(hbk, control=ctrl1)
```

---

CovControlSest-class  Class 'CovControlSest' - contains control parameters for "CovSest"

Description

This class extends the CovControl class and contains the control parameters for CovSest.

Objects from the Class

Objects can be created by calls of the form `new("CovControlSest", ...)` or by calling the constructor-function `CovControlSest`.

Slots

- **bdp** a numeric value specifying the required breakdown point. Allowed values are between \((n - p)/(2 \times n)\) and 1 and the default is \(bdp=0.45\).
- **arp** a numeric value specifying the asymptotic rejection point (for the Rocke type S estimates), i.e. the fraction of points receiving zero weight (see Rocke (1996)). Default is \(arp=0.1\).
- **eps** a numeric value specifying the relative precision of the solution of the S-estimate (bisquare and Rocke type). Default is \(eps=1e-5\).
- **maxiter** maximum number of iterations allowed in the computation of the S-estimate (bisquare and Rocke type). Default is \(maxiter=120\).
- **nsamp** the number of random subsets considered. Default is \(nsamp = 500\).
- **seed** starting value for random generator. Default is \(seed = NULL\).
- **method** Which algorithm to use: 'fast'=FAST-S, 'surreal'=Ruppert’s SURREAL algorithm, 'bisquare'=Bisquare S-estimation with HBDD start or 'rocke' for Rocke type S-estimates
- **trace**, **tolsolve**: from the "CovControl" class.

Extends

Class "CovControl", directly.
Methods

`restimate` signature(obj = "CovControlSest"): the generic function `restimate` allows the different methods for robust estimation to be used polymorphically - this function will call `CovSest` passing it the control object and will return the obtained `CovRobust` object.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


Examples

```r
## the following two statements are equivalent
ctrl1 <- new("CovControlSest", bdp=0.4)
ctrl2 <- CovControlSest(bdp=0.4)
data(hbk)
CovSest(hbk, control=ctrl1)
```

Description

Computes a robust multivariate location and scatter estimate with a high breakdown point, using the ‘Fast MCD’ (Minimum Covariance Determinant) estimator.

Usage

```r
CovMcd(x,  
raw.only=FALSE, alpha=control@alpha, nsamp=control@nsamp,  
scalefn=control@scalefn, maxcsteps=control@maxcsteps,  
initHsets=NULL, save.hsets=FALSE,  
seed=control@seed, trace=control@trace,  
use.correction=control@use.correction,  
control=CovControlMcd(), ...)  
```

Arguments

- `x` a matrix or data frame.
- `raw.only` should only the “raw” estimate be returned.
**alpha** numeric parameter controlling the size of the subsets over which the determinant is minimized, i.e., alpha*n observations are used for computing the determinant. Allowed values are between 0.5 and 1 and the default is 0.5.

**nsamp** number of subsets used for initial estimates or "best", "exact" or "deterministic". Default is nsamp = 500. For nsamp="best" exhaustive enumeration is done, as long as the number of trials does not exceed 5000. For "exact", exhaustive enumeration will be attempted however many samples are needed. In this case a warning message will be displayed saying that the computation can take a very long time.

For "deterministic", the **deterministic** MCD is computed; as proposed by Hubert et al. (2012) it starts from the h most central observations of six (deterministic) estimators.

**scalefn** function to compute a robust scale estimate or character string specifying a rule determining such a function, see rrcov.control.

**maxcsteps** maximal number of concentration steps in the deterministic MCD; should not be reached.

**initHsets** NULL or a Kxh integer matrix of initial subsets of observations of size h (specified by the indices in 1:n).

**save.Hsets** (for deterministic MCD) logical indicating if the initial subsets should be returned as initHsets.

**seed** starting value for random generator. Default is seed = NULL.

**trace** whether to print intermediate results. Default is trace = FALSE.

**use.correction** whether to use finite sample correction factors. Default is use.correction=TRUE.

**control** a control object (S4) of class CovControlMcd-class containing estimation options - same as these provided in the function specification. If the control object is supplied, the parameters from it will be used. If parameters are passed also in the invocation statement, they will override the corresponding elements of the control object.

... potential further arguments passed to robustbase's covMcd.

**Details**

This function computes the minimum covariance determinant estimator of location and scatter and returns an S4 object of class CovMcd-class containing the estimates. The implementation of the function is similar to the existing R function covMcd() which returns an S3 object. The MCD method looks for the h(> n/2) observations (out of n) whose classical covariance matrix has the lowest possible determinant. The raw MCD estimate of location is then the average of these h points, whereas the raw MCD estimate of scatter is their covariance matrix, multiplied by a consistency factor and a finite sample correction factor (to make it consistent at the normal model and unbiased at small samples). Both rescaling factors are returned also in the vector raw.cnp2 of length 2. Based on these raw MCD estimates, a reweighting step is performed which increases the finite-sample efficiency considerably - see Pison et al. (2002). The rescaling factors for the reweighted estimates are returned in the vector cnp2 of length 2. Details for the computation of the finite sample correction factors can be found in Pison et al. (2002). The finite sample corrections can be suppressed by setting use.correction=FALSE. The implementation in rrcov uses the Fast MCD algorithm of Rousseeuw and Van Driessen (1999) to approximate the minimum covariance determinant estimator.
Value

An S4 object of class `CovMcd-class` which is a subclass of the virtual class `CovRobust-class`.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

cov.mcd from package MASS

Examples

data(hbk)
hbk.x <- data.matrix(hbk[, 1:3])
CovMcd(hbk.x)
cD <- CovMcd(hbk.x, nsamp = "deterministic")
summary(cD)

## the following three statements are equivalent
c1 <- CovMcd(hbk.x, alpha = 0.75)
c2 <- CovMcd(hbk.x, control = CovControlMcd(alpha = 0.75))
## direct specification overrides control one:
c3 <- CovMcd(hbk.x, alpha = 0.75, 
BUILDING規劃
    control = CovControlMcd(alpha=0.95))
c1

---

**CovMcd-class**

**MCD Estimates of Multivariate Location and Scatter**

Description

This class, derived from the virtual class "CovRobust" accomodates MCD Estimates of multivariate location and scatter computed by the ‘Fast MCD’ algorithm.
Objects from the Class

Objects can be created by calls of the form `new("CovMcd", ...),` but the usual way of creating CovMcd objects is a call to the function `CovMcd` which serves as a constructor.

Slots

- **alpha**: Object of class "numeric" - the size of the subsets over which the determinant is minimized (the default is \((n+p+1)/2\))
- **quan**: Object of class "numeric" - the number of observations on which the MCD is based. If quan equals n.obs, the MCD is the classical covariance matrix.
- **best**: Object of class "Uvector" - the best subset found and used for computing the raw estimates. The size of best is equal to quan
- **raw.cov**: Object of class "matrix" the raw (not reweighted) estimate of location
- **raw.center**: Object of class "vector" - the raw (not reweighted) estimate of scatter
- **raw.mah**: Object of class "Uvector" - mahalanobis distances of the observations based on the raw estimate of the location and scatter
- **raw.wt**: Object of class "Uvector" - weights of the observations based on the raw estimate of the location and scatter
- **raw.cnp2**: Object of class "numeric" - a vector of length two containing the consistency correction factor and the finite sample correction factor of the raw estimate of the covariance matrix
- **cnp2**: Object of class "numeric" - a vector of length two containing the consistency correction factor and the finite sample correction factor of the final estimate of the covariance matrix.
- **iter, crit, wt**: from the "CovRobust" class.
- **call, cov, center, n.obs, mah, method, singularity, X**: from the "Cov" class.

Extends

Class "CovRobust", directly. Class "Cov", by class "CovRobust".

Methods

No methods defined with class "CovMcd" in the signature.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

CovMcd, Cov-class, CovRobust-class
**CovMest**

*Constrained M-Estimates of Location and Scatter*

**Description**

Computes constrained M-Estimates of multivariate location and scatter based on the translated bi-weight function ('t-biweight') using a High breakdown point initial estimate as defined by Rocke (1996). The default initial estimate is the Minimum Volume Ellipsoid computed with `CovMve`. The raw (not reweighted) estimates are taken and the covariance matrix is standardized to determinant 1.

**Usage**

```r
CovMest(x, r = 0.45, arp = 0.05, eps=1e-3, 
maxiter=120, control, t0, S0, initcontrol)
```

**Arguments**

- **x**: a matrix or data frame.
- **r**: required breakdown point. Allowed values are between \((n - p)/(2 \times n)\) and 1 and the default is 0.45
- **arp**: asymptotic rejection point, i.e. the fraction of points receiving zero weight (see Rocke (1996)). Default is 0.05.
- **eps**: a numeric value specifying the relative precision of the solution of the M-estimate. Defaults to `1e-3`
- **maxiter**: maximum number of iterations allowed in the computation of the M-estimate. Defaults to 120
- **control**: a control object (S4) of class `CovControlMest-class` containing estimation options - same as these provided in the function specification. If the control object is supplied, the parameters from it will be used. If parameters are passed also in the invocation statement, they will override the corresponding elements of the control object.
- **t0**: optional initial high breakdown point estimates of the location. If not supplied MVE will be used.
- **S0**: optional initial high breakdown point estimates of the scatter. If not supplied MVE will be used.
- **initcontrol**: optional control object - of class CovControl - specifying the initial high breakdown point estimates of location and scatter. If not supplied MVE will be used.

**Examples**

```r
showClass("CovMcd")
```
Details

Rocke (1996) has shown that the S-estimates of multivariate location and scatter in high dimensions can be sensitive to outliers even if the breakdown point is set to be near 0.5. To mitigate this problem he proposed to utilize the translated biweight (or t-biweight) method with a standardization step consisting of equating the median of \( \rho_H(d) \) with the median under normality. This is then not an S-estimate, but is instead a constrained M-estimate. In order to make the smooth estimators to work, a reasonable starting point is necessary, which will lead reliably to a good solution of the estimator. In CovMest the MVE computed by CovMve is used, but the user has the possibility to give her own initial estimates.

Value

An object of class CovMest-class which is a subclass of the virtual class CovRobust-class.

Note

The psi, rho and weight functions for the M estimation are encapsulated in a virtual S4 class PsiFun from which a PsiBwt class, implementing the translated biweight (t-biweight), is derived. The base class PsiFun contains also the M-iteration itself. Although not documented and not accessible directly by the user these classes will form the bases for adding other functions (biweight, LWS, etc.) as well as S-estimates.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>,

(some code from C. Becker - http://www.sfb475.uni-dortmund.de/dienst/de/content/struk-d/bereicha-d/tpa1softw-d.html)

References


See Also
covMcd, Cov-class, CovMve, CovRobust-class, CovMest-class
Examples

```r
library(rrcov)
data(hbk)
hbk.x <- data.matrix(hbk[, 1:3])
CovMest(hbk.x)

## the following four statements are equivalent
c0 <- CovMest(hbk.x)
c1 <- CovMest(hbk.x, r = 0.45)
c2 <- CovMest(hbk.x, control = CovControlMest(r = 0.45))
c3 <- CovMest(hbk.x, control = new("CovControlMest", r = 0.45))

## direct specification overrides control one:
c4 <- CovMest(hbk.x, r = 0.40, control = CovControlMest(r = 0.25))
c1
summary(c1)
plot(c1)
```

covMest

*Constrained M-Estimates of Location and Scatter*

Description

Computes constrained M-Estimates of multivariate location and scatter based on the translated bi-weight function (‘t-biweight’) using a High breakdown point initial estimate. The default initial estimate is the Minimum Volume Ellipsoid computed with `CovMve`. The raw (not reweighted) estimates are taken and the covariance matrix is standardized to determinant 1.

Usage

```r
covMest(x, cor=FALSE, r = 0.45, arp = 0.05, eps=1e-3, maxiter=120, control, t0, S0)
```

Arguments

- `x` a matrix or data frame.
- `cor` should the returned result include a correlation matrix? Default is `cor = FALSE`.
- `r` required breakdown point. Allowed values are between \((n - p)/(2 \times n)\) and 1 and the default is 0.45
- `arp` asymptotic rejection point, i.e. the fraction of points receiving zero weight (see Rocke (1996)). Default is 0.05.
- `eps` a numeric value specifying the relative precision of the solution of the M-estimate. Defaults to 1e-3
- `maxiter` maximum number of iterations allowed in the computation of the M-estimate. Defaults to 120
covMest

control a list with estimation options - same as these provided in the function specification. If the control object is supplied, the parameters from it will be used. If parameters are passed also in the invocation statement, they will override the corresponding elements of the control object.

t₀ optional initial high breakdown point estimates of the location. If not supplied MVE will be used.

S₀ optional initial high breakdown point estimates of the scatter. If not supplied MVE will be used.

Details

Rocke (1996) has shown that the S-estimates of multivariate location and scatter in high dimensions can be sensitive to outliers even if the breakdown point is set to be near 0.5. To mitigate this problem he proposed to utilize the translated biweight (or t-biweight) method with a standardization step consisting of equating the median of \( \rho_H(d) \) with the median under normality. This is then not an S-estimate, but is instead a constrained M-estimate. In order to make the smooth estimators to work, a reasonable starting point is necessary, which will lead reliably to a good solution of the estimator.

In covMest the MVE computed by CovMve is used, but the user has the possibility to give her own initial estimates.

Value

An object of class "mest" which is basically a list with the following components. This class is "derived" from "mcd" so that the same generic functions - print, plot, summary - can be used. NOTE: this is going to change - in one of the next revisions covMest will return an S4 class "mest" which is derived (i.e. contains) form class "cov".

center the final estimate of location.
cov the final estimate of scatter.
cor the estimate of the correlation matrix (only if cor = TRUE).
mah mahalanobis distances of the observations using the M-estimate of the location and scatter.
x the input data as a matrix.
n.obs total number of observations.
method character string naming the method (M-Estimates).
call the call used (see match.call).

Note

The psi, rho and weight functions for the M estimation are encapsulated in a virtual S4 class Psifun from which a Psibwt class, implementing the translated biweight (t-biweight), is derived. The base class Psifun contains also the M-iteration itself. Although not documented and not accessibale directly by the user these classes will form the bases for adding other functions (biweight, LWS, etc.) as well as S-estimates.
Author(s)
Valentin Todorov <valentin.todorov@chello.at>,
(some code from C. Becker - http://www.sfb475.uni-dortmund.de/dienst/de/content/strukt-d/bereich-d/tpa1softw-d.html)

References

See Also
covMcd

CovMest-class

Constrained M-estimates of Multivariate Location and Scatter

Description
This class, derived from the virtual class "CovRobust" accomodates constrained M-Estimates of multivariate location and scatter based on the translated biweight function ('t-biweight') using a High breakdown point initial estimate (Minimum Covariance Determinant - 'Fast MCD')

Objects from the Class
Objects can be created by calls of the form new("CovMest", ...), but the usual way of creating CovMest objects is a call to the function CovMest which serves as a constructor.

Slots

vt: Object of class "vector" - vector of weights (v)
iter, crit, wt: from the "CovRobust" class.
call, cov, center, n.obs, mah, method, singularity, X: from the "Cov" class.

Extends
Class "CovRobust", directly. Class "Cov", by class "CovRobust".
Methods

No methods defined with class "CovMest" in the signature.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

CovMest, Cov-class, CovRobust-class

Examples

showClass("CovMest")

CovMMest                MM Estimates of Multivariate Location and Scatter

Description

Computes MM-Estimates of multivariate location and scatter starting from an initial S-estimate

Usage

CovMMest(x, bdp = 0.5, eff = 0.95, eff.shape=TRUE, maxiter = 50, 
trace = FALSE, tolSolve = 1e-7, control)

Arguments

x                a matrix or data frame.
bdp              a numeric value specifying the required breakdown point. Allowed values are 
between 0.5 and 1 and the default is bdp=0.5.
eff              a numeric value specifying the required efficiency for the MM estimates. De-
default is eff=0.95.
eff.shape       logical; if TRUE, eff is with regard to shape-efficiency, otherwise location-
efficiency. Default is eff.shape=FALSE.
maxiter          maximum number of iterations allowed in the computation of the S-estimate 
(bisquare and Rocke type). Default is maxiter=50.
trace            whether to print intermediate results. Default is trace = FALSE.
tolSolve         numeric tolerance to be used as a convergence tolerance for the MM-iteration
control a control object (S4) of class CovControlMMest-class containing estimation options - same as these provided in the function specification. If the control object is supplied, the parameters from it will be used. If parameters are passed also in the invocation statement, they will override the corresponding elements of the control object.

Details

Computes MM-estimates of multivariate location and scatter starting from an initial S-estimate.

Value

An S4 object of class CovMMest-class which is a subclass of the virtual class CovRobust-class.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


Examples

library(rrcov)
data(hbk)
hbk.x <- data.matrix(hbk[, 1:3])
CovMMest(hbk.x)

## the following four statements are equivalent
c0 <- CovMMest(hbk.x)
c1 <- CovMMest(hbk.x, bdp = 0.25)
c2 <- CovMMest(hbk.x, control = CovControlMMest(bdp = 0.25))
c3 <- CovMMest(hbk.x, control = new("CovControlMMest", bdp = 0.25))

## direct specification overrides control one:
c4 <- CovMMest(hbk.x, bdp = 0.40,
               control = CovControlMMest(bdp = 0.25))

c1
summary(c1)
plot(c1)
**CovMMest-class**

## Description
This class, derived from the virtual class "CovRobust" accommodates MM Estimates of multivariate location and scatter.

## Objects from the Class
Objects can be created by calls of the form new("CovMMest", ...), but the usual way of creating CovSest objects is a call to the function CovMMest which serves as a constructor.

## Slots
- **det**, **flag**, **iter**, **crit**: from the "CovRobust" class.
- **c1**: tuning parameter of the loss function for MM-estimation (depend on control parameters eff and eff.shape). Can be computed by the internal function .csolve.bw.MM(p, eff, eff.shape=TRUE).
  For the tuning parameters of the underlying S-estimate see the slot sest and "CovSest".
- **sest**: an CovSest object containing the initial S-estimate.

## Extends
Class "CovRobust", directly. Class "Cov", by class "CovRobust".

## Methods
No methods defined with class "CovMMest" in the signature.

## Author(s)
Valentin Todorov <valentin.todorov@chello.at>

## References

## See Also
CovMMest, Cov-class, CovRobust-class
Examples
showClass("CovMve")

CovMve

Robust Location and Scatter Estimation via MVE

Description
Computes a robust multivariate location and scatter estimate with a high breakdown point, using the ‘MVE’ (Minimum Volume Ellipsoid) estimator.

Usage
CovMve(x, alpha = 1/2, nsamp = 500, seed = NULL, trace = FALSE, control)

Arguments
- **x**: a matrix or data frame.
- **alpha**: numeric parameter controlling the size of the subsets over which the determinant is minimized, i.e., \( \alpha \times n \) observations are used for computing the determinant. Allowed values are between 0.5 and 1 and the default is 0.5.
- **nsamp**: number of subsets used for initial estimates or "best" or "exact". Default is nsamp = 500. For nsamp="best" exhaustive enumeration is done, as long as the number of trials does not exceed 5000. For "exact", exhaustive enumeration will be attempted however many samples are needed. In this case a warning message will be displayed saying that the computation can take a very long time.
- **seed**: starting value for random generator. Default is seed = NULL
- **trace**: whether to print intermediate results. Default is trace = FALSE
- **control**: a control object (S4) of class CovControlMve-class containing estimation options - same as these provided in the function specification. If the control object is supplied, the parameters from it will be used. If parameters are passed also in the invocation statement, they will override the corresponding elements of the control object.

Details
This function computes the minimum volume ellipsoid estimator of location and scatter and returns an S4 object of class CovMve-class containing the estimates.

The approximate estimate is based on a subset of size \( \alpha \times n \) with an enclosing ellipsoid of smallest volume. The mean of the best found subset provides the raw estimate of the location, and the rescaled covariance matrix is the raw estimate of scatter. The rescaling of the raw covariance matrix is by \( \text{median}(\text{dist})/\text{qchisq}(0.5, p) \) and this scale factor is returned in the slot raw.cnp2. Currently no finite sample correction factor is applied. The Mahalanobis distances of all observations from the location estimate for the raw covariance matrix are calculated, and those points within the
97.5 under Gaussian assumptions are declared to be good. The final (reweighted) estimates are the mean and rescaled covariance of the good points. The reweighted covariance matrix is rescaled by \(1/p\gamma(c\chi^2(\alpha, p)/2, p/2 + 1)/\alpha\) (see Croux and Haesbroeck, 1999) and this scale factor is returned in the slot \(\text{cnpR}\).

The search for the approximate solution is made over ellipsoids determined by the covariance matrix of \(p+1\) of the data points and applying a simple but effective improvement of the subsampling procedure as described in Maronna et al. (2006), p. 198. Although there exists no formal proof of this improvement (as for MCD and LTS), simulations show that it can be recommended as an approximation of the MVE.

**Value**

An S4 object of class `CovMve-class` which is a subclass of the virtual class `CovRobust-class`.

**Note**

Main reason for implementing the MVE estimate was that it is the recommended initial estimate for S estimation (see Maronna et al. (2006), p. 199) and will be used by default in `CovMest` (after removing the correction factors from the covariance matrix and rescaling to determinant 1).

**Author(s)**

Valentin Todorov <valentin.todorov@chello.at> and Matias Salibian-Barrera <matias@stat.ubc.ca>

**References**


**See Also**

cov.mve from package MASS

**Examples**

data(hbk)

```r
hbk.x <- data.matrix(hbk[, 1:3])
CovMve(hbk.x)
```

```r
# the following three statements are equivalent
c1 <- CovMve(hbk.x, alpha = 0.75)
c2 <- CovMve(hbk.x, control = CovControlMve(alpha = 0.75))
# direct specification overrides control one:
c3 <- CovMve(hbk.x, alpha = 0.75,
```
control = CovControlMve(alpha=0.95)

c1

CovMve-class

MVE Estimates of Multivariate Location and Scatter

Description

This class, derived from the virtual class "CovRobust" accommodates MVE Estimates of multivariate location and scatter computed by the 'Fast MVE' algorithm.

Objects from the Class

Objects can be created by calls of the form new("CovMve", ...), but the usual way of creating CovMve objects is a call to the function CovMve which serves as a constructor.

Slots

alpha: Object of class "numeric" - the size of the subsets over which the volume of the ellipsoid is minimized (the default is (n+p+1)/2)
quan: Object of class "numeric" - the number of observations on which the MVE is based. If quan equals n.obs, the MVE is the classical covariance matrix.
best: Object of class "Uvector" - the best subset found and used for computing the raw estimates. The size of best is equal to quan
raw.cov: Object of class "matrix" the raw (not reweighted) estimate of location
raw.center: Object of class "vector" - the raw (not reweighted) estimate of scatter
raw.mah: Object of class "Uvector" - mahalanobis distances of the observations based on the raw estimate of the location and scatter
raw.wt: Object of class "Uvector" - weights of the observations based on the raw estimate of the location and scatter
raw.cnph: Object of class "numeric" - a vector of length two containing the consistency correction factor and the finite sample correction factor of the raw estimate of the covariance matrix
cnp2: Object of class "numeric" - a vector of length two containing the consistency correction factor and the finite sample correction factor of the final estimate of the covariance matrix.
iter, crit, wt: from the "CovRobust" class.
call, cov, center, n.obs, mah, method, singularity, X: from the "Cov" class.

Extends

Class "CovRobust", directly. Class "Cov", by class "CovRobust".

Methods

No methods defined with class "CovMve" in the signature.
Author(s)
Valentin Todorov <valentin.todorov@chello.at>

References

See Also
CovMve, Cov-class, CovRobust-class

Examples
showClass("CovMve")

covogk

Robust Location and Scatter Estimation - Ortogonalized Gnanadesikan-Kettenring (OGK)

Description
Computes a robust multivariate location and scatter estimate with a high breakdown point, using the pairwise algorithm proposed by Marona and Zamar (2002) which in turn is based on the pairwise robust estimator proposed by Gnanadesikan-Kettenring (1972).

Usage
CovOgk(x, niter = 2, beta = 0.9, control)

Arguments
x a matrix or data frame.
niter number of iterations, usually 1 or 2 since iterations beyond the second do not lead to improvement.
beta coverage parameter for the final reweighted estimate
control a control object (S4) of class CovControlOgk-class containing estimation options - same as these provided in the function specification. If the control object is supplied, the parameters from it will be used. If parameters are passed also in the invocation statement, they will override the corresponding elements of the control object. The control object contains also functions for computing the robust univariate location and dispersion estimate mrob and for computing the robust estimate of the covariance between two random variables vrob.
Details

The method proposed by Marona and Zamar (2002) allows to obtain positive-definite and almost affine equivariant robust scatter matrices starting from any pairwise robust scatter matrix. The default robust estimate of covariance between two random vectors used is the one proposed by Gnanadesikan and Kettenring (1972) but the user can choose any other method by redefining the function in slot vrob of the control object CovControl0gk. Similarly, the function for computing the robust univariate location and dispersion used is the tau scale defined in Yohai and Zamar (1998) but it can be redefined in the control object.

The estimates obtained by the OGK method, similarly as in CovMcd are returned as 'raw' estimates. To improve the estimates a reweighting step is performed using the coverage parameter beta and these reweighted estimates are returned as 'final' estimates.

Value

An S4 object of class CovOgk-class which is a subclass of the virtual class CovRobust-class.

Note

If the user does not specify a scale and covariance function to be used in the computations or specifies one by using the arguments smrob and svrob (i.e. the names of the functions as strings), a native code written in C will be called which is by far faster than the R version.

If the arguments mrob and vrob are not NULL, the specified functions will be used via the pure R implementation of the algorithm. This could be quite slow.

See CovControl0gk for details.

Author(s)

Valentin Todorov <valentin.todorov@chello.at> and Kjell Konis <kjell.konis@epfl.ch>

References


See Also

CovMcd, CovMest
CovOgk-class

Examples

```r
data(hbk)
hbk.x <- data.matrix(hbk[, 1:3])
CovOgk(hbk.x)

## the following three statements are equivalent
c1 <- CovOgk(hbk.x, niter=1)
c2 <- CovOgk(hbk.x, control = CovControlOgk(niter=1))

## direct specification overrides control one:
c3 <- CovOgk(hbk.x, beta=0.95,
              control = CovControlOgk(beta=0.99))

c1

x<-matrix(c(1,2,3,7,1,2,3,7), ncol=2)
## CovOgk(x) - this would fail because the two columns of x are exactly collinear.
## In order to fix it, redefine the default 'vrob' function for example
## in the following way and pass it as a parameter in the control
## object.
c <- CovOgk(x, control=new("CovControlOgk",
              vrob=function(x1, x2, ...)
              {
                r <- .vrobGK(x1, x2, ...)
                if(is.na(r))
                  r <- 0
                r
              })

cc
c
```

CovOgk-class  O GK Estimates of Multivariate Location and Scatter

Description

This class, derived from the virtual class "CovRobust" accomodates OGK Estimates of multivariate location and scatter computed by the algorithm proposed by Marona and Zamar (2002).

Objects from the Class

Objects can be created by calls of the form `new("CovOgk", ...),` but the usual way of creating `CovOgk` objects is a call to the function `CovOgk` which serves as a constructor.

Slots

- `raw.cov`: Object of class "matrix" the raw (not reweighted) estimate of covariance matrix
- `raw.center`: Object of class "vector" - the raw (not reweighted) estimate of the location vector
- `raw.mah`: Object of class "Uvector" - mahalanobis distances of the observations based on the raw estimate of the location and scatter
raw.wt: Object of class "uvector" - weights of the observations based on the raw estimate of the location and scatter

iter, crit, wt: from the "CovRobust" class.
call, cov, center, n.obs, mah, method, singularity, X: from the "Cov" class.

Extends

Class "CovRobust", directly. Class "Cov", by class "CovRobust".

Methods

No methods defined with class "CovOgk" in the signature.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

CovMcd-class, CovMest-class

Examples

showClass("CovOgk")

---

CovRobust  Robust Location and Scatter Estimation

Description

Computes a robust multivariate location and scatter estimate with a high breakdown point, using one of the available estimators.

Usage

CovRobust(x, control, na.action = na.fail)
Arguments

- **x**: a matrix or data frame.
- **control**: a control object (S4) for one of the available control classes, e.g. `CovControlMcd-class`, `CovControlOgk-class`, `CovControlSest-class`, etc., containing estimation options. The class of this object defines which estimator will be used. Alternatively a character string can be specified which names the estimator - one of auto, sde, mcd, ogk, m, mve, sfast, surreal, bisquare, rocke. If ’auto’ is specified or the argument is missing, the function will select the estimator (see below for details).
- **na.action**: A function to specify the action to be taken if missing values are found. The default action is for the procedure to fail. An alternative is `na.omit`, which leads to rejection of cases with missing values on any required variable.

Details

This function simply calls the `restimate` method of the control object `control`. If a character string naming an estimator is specified, a new control object will be created and used (with default estimation options). If this argument is missing or a character string ’auto’ is specified, the function will select the robust estimator according to the size of the dataset. If there are less than 1000 observations and less than 10 variables or less than 5000 observations and less than 5 variables, Stahel-Donoho estimator will be used. Otherwise, if there are less than 5000 observations either bisquare S-estimates (for less than 10 variables) or Rocke type S-estimates (for 10 to 20 variables) will be used. In both cases the S iteration starts at the initial MVE estimate. And finally, if there are more than 50000 observations and/or more than 20 variables the Orthogonalized Quadrant Correlation estimator (`covogk` with the corresponding parameters) is used.

Value

An object derived from a CovRobust object, depending on the selected estimator.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


Examples

```r
data(hbk)
hbk.x <- data.matrix(hbk[, 1:3])
CovRobust(hbk.x)
CovRobust(hbk.x, CovControlSest(method="bisquare"))
```
CovRobust-class

Class "CovRobust" - virtual base class for robust estimates of multivariate location and scatter

Description

CovRobust is a virtual base class used for deriving the concrete classes representing different robust estimates of multivariate location and scatter. Here are implemented the standard methods common for all robust estimates like show, summary and plot. The derived classes can override these methods and can define new ones.

Objects from the Class

A virtual Class: No objects may be created from it.

Slots

iter: number of iterations used to compute the estimates
crit: value of the criterion function
wt: weights
call, cov, center, n.obs, mah, method, singularity, X: from the "Cov" class.

Extends

Class "Cov", directly.

Methods

isClassic signature(obj = "CovRobust"): Will return FALSE, since this is a 'Robust' object
getMeth signature(obj = "CovRobust"): Return the name of the particular robust method used (as a character string)
show signature(object = "CovRobust"): display the object
plot signature(x = "CovRobust"): plot the object
getRaw signature(obj = "CovRobust"): Return the object with the reweighted estimates replaced by the raw ones (only relevant for CovMcd, CovMve and CovOgk)

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References

CovSde

See Also
Cov-class, CovMcd-class, CovMest-class, CovOgk-class

Examples

data(hbk)
hbk.x <- data.matrix(hbk[, 1:3])
cv <- CovMest(hbk.x) # it is not possible to create an object of
class CovRobust, since it is a VIRTUAL class
summary(cv) # summary method for class CovRobust
plot(cv) # plot method for class CovRobust

CovSde
Stahel-Donoho Estimates of Multivariate Location and Scatter

Description
Compute a robust estimate of location and scale using the Stahel-Donoho projection based estimator

Usage
CovSde(x, nsamp, maxres, tune = 0.95, eps = 0.5, prob = 0.99,
seed = NULL, trace = FALSE, control)

Arguments
x a matrix or data frame.
nsamp a positive integer giving the number of resamples required; nsamp may not be reached if too many of the p-subsamples, chosen out of the observed vectors, are in a hyperplane. If nsamp = 0 all possible subsamples are taken. If nsamp is omitted, it is calculated to provide a breakdown point of eps with probability prob.
maxres a positive integer specifying the maximum number of resamples to be performed including those that are discarded due to linearly dependent subsamples. If maxres is omitted it will be set to 2 times nsamp.
tune a numeric value between 0 and 1 giving the fraction of the data to receive non-zero weight. Defaults to 0.95
prob a numeric value between 0 and 1 specifying the probability of high breakdown point; used to compute nsamp when nsamp is omitted. Defaults to 0.99.
eps a numeric value between 0 and 0.5 specifying the breakdown point; used to compute nsamp when nsamp is omitted. Defaults to 0.5.
seed starting value for random generator. Default is seed = NULL.
trace whether to print intermediate results. Default is trace = FALSE.
control

a control object (S4) of class `CovControlSde-class` containing estimation options - same as these provided in the function specification. If the control object is supplied, the parameters from it will be used. If parameters are passed also in the invocation statement, they will override the corresponding elements of the control object.

Details

The projection based Stahel-Donoho estimator possesses very good statistical properties, but it can be very slow if the number of variables is too large. It is recommended to use this estimator if \( n \leq 1000 \) and \( p \leq 10 \) or \( n \leq 5000 \) and \( p \leq 5 \). The number of subsamples required is calculated to provide a breakdown point of \( \varepsilon \) with probability \( \text{prob} \) and can reach values larger than the larger integer value - in such case it is limited to \( \text{Machine}\$\text{integer}\$.max \). Of course you could provide \( \text{nsamp} \) in the call, i.e. \( \text{nsamp}=1000 \) but this will not guarantee the required breakdown point of the estimator. For larger data sets it is better to use `CovMcd` or `CovOgk`. If you use `CovRobust`, the estimator will be selected automatically according to the size of the data set.

Value

An S4 object of class `CovSde-class` which is a subclass of the virtual class `CovRobust-class`.

Note

The Fortran code for the Stahel-Donoho method was taken almost with no changes from package `robust` which in turn has it from the `Insightful Robust Library` (thanks to by Kjell Konis).

Author(s)

Valentin Todorov <valentin.todorov@chello.at> and Kjell Konis <kjell.konis@epfl.ch>

References


Examples

data(hbk)
hbk.x <- data.matrix(hbk[, 1:3])
CovSde(hbk.x)

## the following four statements are equivalent
c0 <- CovSde(hbk.x)
c1 <- CovSde(hbk.x, nsamp=2000)
c2 <- CovSde(hbk.x, control = CovControlSde(nsamp=2000))
c3 <- CovSde(hbk.x, control = new("CovControlSde", nsamp=2000))
CovSde-class

Description

This class, derived from the virtual class "CovRobust" accommodates Stahel-Donoho estimates of multivariate location and scatter.

Objects from the Class

Objects can be created by calls of the form new("CovSde", ...), but the usual way of creating CovSde objects is a call to the function CovSde which serves as a constructor.

Slots

iter, crit, wt: from the "CovRobust" class.
call, cov, center, n.obs, mah, method, singularity, X: from the "Cov" class.

Extends

Class "CovRobust", directly. Class "Cov", by class "CovRobust".

Methods

No methods defined with class "CovSde" in the signature.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References

See Also

covsde, cov-class, CovRobust-class

Examples

showClass("CovSde")

CovSest  

S Estimates of Multivariate Location and Scatter

Description

Computes S-Estimates of multivariate location and scatter based on Tukey’s biweight function using a fast algorithm similar to the one proposed by Salibian-Barrera and Yohai (2006) for the case of regression. Alternativley, the Ruppert’s SURREAL algorithm, bisquare or Rocke type estimation can be used.

Usage

CovSest(x, bdp = 0.5, arp = 0.1, eps = 1e-5, maxiter = 120, nsamp = 500, seed = NULL, trace = FALSE, tolsolve = 1e-14, scalefn, maxisteps=200, initHsets = NULL, save.hsets = FALSE, method = c("sfast", "surreal", "bisquare", "rocke", "suser", "sdet"), control, t0, S0, initcontrol)

Arguments

x  
a matrix or data frame.
bdp  
a numeric value specifying the required breakdown point. Allowed values are between \((n - p)/(2 * n)\) and 1 and the default is bdp=0.5.
arp  
a numeric value specifying the asymptotic rejection point (for the Rocke type S estimates), i.e. the fraction of points receiving zero weight (see Rocke (1996)). Default is arp=0.1.
eps  
a numeric value specifying the relative precision of the solution of the S-estimate (bisquare and Rocke type). Default is to eps=1e-5.
maxiter  
maximum number of iterations allowed in the computation of the S-estimate (bisquare and Rocke type). Default is maxiter=120.
nsamp  
the number of random subsets considered. The default is different for the different methods: (i) for sfast it is nsamp = 20, (ii) for surreal it is nsamp = 600*p and (iii) for bisquare or rocke it is nsamp = 500.
seed  
starting value for random generator. Default is seed = NULL.
trace  
whether to print intermediate results. Default is trace = FALSE.
tolSolve  
numeric tolerance to be used for inversion (solve) of the covariance matrix in mahalanobis.
scalefn function to compute a robust scale estimate or character string specifying a rule determining such a function. Used for computing the "deterministic" S-estimates (method="sdet"). If scalefn is missing or is NULL, the function is selected depending on the data set size, following the recommendation of Hubert et al. (2012) - \( \text{qn} \) if \( n \leq 1000 \) and \( \text{scaleTau2} \) otherwise.

maxisteps maximal number of concentration steps in the deterministic S-estimates; should not be reached.

inithsets NULL or a \( K \times n \) integer matrix of initial subsets of observations of size (specified by the indices in \( 1:n \)).

save.Hsets (for deterministic S-estimates) logical indicating if the initial subsets should be returned as inithsets.

method Which algorithm to use: 'sfast'=C implementation of FAST-S, 'surreal'=SURREAL, 'bisquare', 'rocke'. The method 'suser' currently calls the R implementation of FAST-S but in the future will allow the user to supply own rho function. The method 'sdet' invokes the deterministic algorithm of Hubert et al. (2012).

control a control object (S4) of class CovControlSest-class containing estimation options - same as these provided in the function specification. If the control object is supplied, the parameters from it will be used. If parameters are passed also in the invocation statement, they will override the corresponding elements of the control object.

t0 optional initial HBDP estimate for the center

S0 optional initial HBDP estimate for the covariance matrix

initcontrol optional control object to be used for computing the initial HBDP estimates

Details
Computes multivariate S-estimator of location and scatter. The computation will be performed by one of the following algorithms:

**FAST-S** An algorithm similar to the one proposed by Salibian-Barrera and Yohai (2006) for the case of regression

**SURREAL** Ruppert’s SURREAL algorithm when method is set to ‘surreal’

**BISQUARE** Bisquare S-Estimate with method set to ‘bisquare’

**ROCKE** Rocke type S-Estimate with method set to ‘rocke’

Except for the last algorithm, ROCKE, all other use Tukey biweight loss function. The tuning parameters used in the loss function (as determined by bdp) are returned in the slots cc and kp of the result object. They can be computed by the internal function .csolve.bw.S(bdp, p).

Value
An S4 object of class CovSest-class which is a subclass of the virtual class CovRobust-class.

Author(s)
Valentin Todorov <valentin.todorov@chello.at>, Matias Salibian-Barrera <matias@stat.ubc.ca> and Victor Yohai <vyohai@dm.uba.ar>. See also the code from Kristel Joossens, K.U. Leuven, Belgium and Ella Roelant, Ghent University, Belgium.
References


Examples

```r
library(rrcov)
data(hbk)
hbk.x <- data.matrix(hbk[, 1:3])
cc <- CovSest(hbk.x)
cc

## summary and different types of plots
summary(cc)
plot(cc)
plot(cc, which="dd")
plot(cc, which="pairs")
plot(cc, which="xydist")

## the following four statements are equivalent
co <- CovSest(hbk.x)
c1 <- CovSest(hbk.x, bdp = 0.25)
c2 <- CovSest(hbk.x, control = CovControlSest(bdp = 0.25))
c3 <- CovSest(hbk.x, control = new("CovControlSest", bdp = 0.25))

## direct specification overrides control one:
c4 <- CovSest(hbk.x, bdp = 0.40,
control = CovControlSest(bdp = 0.25))
c1
summary(c1)
plot(c1)

## Use the SURREAL algorithm of Ruppert
cr <- CovSest(hbk.x, method="surreal")
cr
```
CovSest-class

## Use Bisquare estimation
```r
cr <- CovSest(hbk.x, method="bisquare")
```

## Use Rocke type estimation
```r
cr <- CovSest(hbk.x, method="rocke")
```

## Use Deterministic estimation
```r
cr <- CovSest(hbk.x, method="sdet")
```

---

**CovSest-class**  
*S Estimates of Multivariate Location and Scatter*

### Description
This class, derived from the virtual class "CovRobust" accommodates S Estimates of multivariate location and scatter computed by the ‘Fast S’ or ‘SURREAL’ algorithm.

### Objects from the Class
Objects can be created by calls of the form `new("CovSest", ...)`, but the usual way of creating CovSest objects is a call to the function `covSest` which serves as a constructor.

### Slots
- `iter, crit, wt`: from the "CovRobust" class.
- `ibest, nsteps, initHsets`: parameters for deterministic S-estimator (the best initial subset, number of concentration steps to convergence for each of the initial subsets, and the computed initial subsets, respectively).
- `cc, kp`: tuning parameters used in Tukey biweight loss function, as determined by bdp. Can be computed by the internal function .csolve.bw.S(bdp, p).
- `call, cov, center, n.obs, mah, method, singularity, X`: from the "Cov" class.

### Extends
Class "CovRobust", directly. Class "Cov", by class "CovRobust".

### Methods
No methods defined with class "CovSest" in the signature.

### Author(s)
Valentin Todorov <valentin.todorov@chello.at>
References


See Also

`covsest`, `cov-class`, `CovRobust-class`

Examples

```r
showClass("CovSest")
```

---

**fish**  
*Fish Catch Data Set*

**Description**

The Fish Catch data set contains measurements on 159 fish caught in the lake Laengelmavesi, Finland.

**Usage**

data(fish)

**Format**

A data frame with 159 observations on the following 7 variables.

- **Weight**  
  Weight of the fish (in grams)

- **Length1**  
  Length from the nose to the beginning of the tail (in cm)

- **Length2**  
  Length from the nose to the notch of the tail (in cm)

- **Length3**  
  Length from the nose to the end of the tail (in cm)

- **Height**  
  Maximal height as % of Length3

- **Width**  
  Maximal width as % of Length3

- **Species**  
  Species

**Details**

The Fish Catch data set contains measurements on 159 fish caught in the lake Laengelmavesi, Finland. For the 159 fishes of 7 species the weight, length, height, and width were measured. Three different length measurements are recorded: from the nose of the fish to the beginning of its tail, from the nose to the notch of its tail and from the nose to the end of its tail. The height and width are calculated as percentages of the third length variable. This results in 6 observed variables, Weight, Length1, Length2, Length3, Height, Width. Observation 14 has a missing value in variable Weight, therefore this observation is usually excluded from the analysis. The last variable, Species, represents the grouping structure: the 7 species are 1=Bream, 2=Whitewish, 3=Roach, 4=Parkki, 5=Smelt, 6=Pike, 7=Perch. This data set was also analyzed in the context of robust Linear Discriminant Analysis by Todorov (2007), Todorov and Pires (2007).
Source


References


Examples

data(fish)

# remove observation #14 containing missing value
fish <- fish[-14,]

# The height and width are calculated as percentages
# of the third length variable
fish[,5] <- fish[,5]*fish[,4]/100
fish[,6] <- fish[,6]*fish[,4]/100

# plot a matrix of scatterplots
pairs(fish[1:6],
    main="Fish Catch Data",
    pch=21,
    bg=c("red", "green3", "blue", "yellow", "magenta", "violet",
    "turquoise")[unclass(fish$Species)])

---

### Description

Accessor methods to the slots of objects of class `Cov` and its subclasses

### Usage

- `getCenter(obj)`
- `getCov(obj)`
- `getCorr(obj)`
- `getData(obj)`
- `getDistance(obj)`
- `getEvals(obj)`
- `getDet(obj)`
- `getShape(obj)`
getFlag(obj, prob=0.975)
getMeth(obj)
isClassic(obj)
getRaw(obj)

Arguments

<table>
<thead>
<tr>
<th>obj</th>
<th>an object of class &quot;Cov&quot; or of a class derived from &quot;Cov&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>prob</td>
<td>optional argument for getFlag - probability, defaults to 0.975</td>
</tr>
</tbody>
</table>

Methods

**obj = "Cov"**
- generic functions - see getCenter, getCov, getCorr, getData, getDistance, getEvals, getDet, getShape, getFlag, isClassic

**obj = "CovRobust"**
- generic functions - see getCenter, getCov, getCorr, getData, getDistance, getEvals, getDet, getShape, getFlag, getMeth, isClassic

---

getLoadings-methods  
**Accessor methods to the essential slots of Pca and its subclasses**

Description

Accessor methods to the slots of objects of class Pca and its subclasses

Arguments

| obj       | an object of class "Pca" or of a class derived from "Pca" |

Methods

**obj = "Pca"**  
Accessors for object of class Pca

**obj = "PcaRobust"**  
Accessors for object of class PcaRobust

**obj = "PcaClassic"**  
Accessors for object of class PcaClassic
hemophilia

Hemophilia Data

Description
The hemophilia data set contains two measured variables on 75 women, belonging to two groups: n1=30 of them are non-carriers (normal group) and n2=45 are known hemophilia A carriers (obligatory carriers).

Usage
data(hemophilia)

Format
A data frame with 75 observations on the following 3 variables.

AHFactivity  AHF activity
AHFantigen  AHF antigen
gr  group - normal or obligatory carrier

Details
Originally analyzed in the context of discriminant analysis by Habemma and Hermans (1974). The objective is to find a procedure for detecting potential hemophilia A carriers on the basis of two measured variables: X1=log10(AHV activity) and X2=log10(AHV-like antigen). The first group of n1=30 women consists of known non-carriers (normal group) and the second group of n2=45 women is selected from known hemophilia A carriers (obligatory carriers). This data set was also analyzed by Johnson and Wichern (1998) as well as, in the context of robust Linear Discriminant Analysis by Hawkins and McLachlan (1997) and Hubert and Van Driessen (2004).

Source

References


### isSingular-methods

Check if a covariance matrix (object of class 'Cov') is singular

#### Description

Returns TRUE if the covariance matrix contained in a **Cov-class** object (or derived from) is singular.

#### Usage

```r
## S4 method for signature 'Cov'
isSingular(obj)
```

#### Arguments

- **obj**: an object of class (derived from) "Cov".

#### Methods

- **isSingular** signature(x = Cov): Check if a covariance matrix (object of class **Cov-class**) is singular.

#### See Also

- **Cov-class, CovClassic, CovRobust-class**.

#### Examples

```r
data(hbk)
cc <- CovClassic(hbk)
isSingular(cc)
```
Class "Lda" - virtual base class for all classic and robust LDA classes

Description

The class Lda serves as a base class for deriving all other classes representing the results of classical and robust Linear Discriminant Analysis methods.

Objects from the Class

A virtual Class: No objects may be created from it.

Slots

call: the (matched) function call.
prior: prior probabilities used, default to group proportions
counts: number of observations in each class
center: the group means
cov: the common covariance matrix
ldf: a matrix containing the linear discriminant functions
ldfconst: a vector containing the constants of each linear discriminant function
method: a character string giving the estimation method used
X: the training data set (same as the input parameter x of the constructor function)
grp: grouping variable: a factor specifying the class for each observation.

Methods

predict signature(object = "Lda"): calculates prediction using the results in object. An optional data frame or matrix in which to look for variables with which to predict. If omitted, the training data set is used. If the original fit used a formula or a data frame or a matrix with column names, newdata must contain columns with the same names. Otherwise it must contain the same number of columns, to be used in the same order.

show signature(object = "Lda"): prints the results

summary signature(object = "Lda"): prints summary information

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References

**See Also**

LdaClassic, LdaClassic-class, LdaRobust-class

**Examples**

showClass("Lda")

---

**LdaClassic  Linear Discriminant Analysis**

**Description**

Performs a linear discriminant analysis and returns the results as an object of class LdaClassic (aka constructor).

**Usage**

LdaClassic(x, ...)

## Default S3 method:
LdaClassic(x, grouping, prior = proportions, tol = 1.0e-4, ...)

**Arguments**

- **x**
  - a matrix or data frame containing the explanatory variables (training set).
- **grouping**
  - grouping variable: a factor specifying the class for each observation.
- **prior**
  - prior probabilities, default to the class proportions for the training set.
- **tol**
  - tolerance
- **...**
  - arguments passed to or from other methods.

**Value**

Returns an S4 object of class LdaClassic

**Author(s)**

Valentin Todorov <valentin.todorov@chello.at>

**References**


**See Also**

Lda-class, LdaClassic-class,
**Examples**

```r
## Example anorexia
library(MASS)
data(anorexia)

## rrcov: LdaClassic()
lda <- LdaClassic(Treat~., data=anorexia)
predict(lda)$classification

## MASS: lda()
lda.MASS <- lda(Treat~., data=anorexia)
predict(lda.MASS)$class

## Compare the prediction results of MASS::lda() and LdaClassic()
all.equal(predict(lda)$classification, predict(lda.MASS)$class)
```

---

**LdaClassic-class**  
*Class "LdaClassic" - Linear Discriminant Analysis*

**Description**

Contains the results of a classical Linear Discriminant Analysis

**Objects from the Class**

Objects can be created by calls of the form `new("LdaClassic", ...)` but the usual way of creating `LdaClassic` objects is a call to the function `LdaClassic` which serves as a constructor.

**Slots**

- **call**: The (matched) function call.
- **prior**: Prior probabilities used, default to group proportions
- **counts**: number of observations in each class
- **center**: the group means
- **cov**: the common covariance matrix
- **ldf**: a matrix containing the linear discriminant functions
- **ldfconst**: a vector containing the constants of each linear discriminant function
- **method**: a character string giving the estimation method used
- **X**: the training data set (same as the input parameter `x` of the constructor function)
- **grp**: grouping variable: a factor specifying the class for each observation.

**Extends**

Class "Lda", directly.
Methods

No methods defined with class "LdaClassic" in the signature.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

LdaRobust-class, Lda-class, LdaClassic

Examples

showClass("LdaClassic")

LdaPP

*Robust Linear Discriminant Analysis by Projection Pursuit*

Description

Performs robust linear discriminant analysis by the projection-pursuit approach - proposed by Pires and Branco (2010) - and returns the results as an object of class LdaPP (aka constructor).

Usage

LdaPP(x, ...)

## S3 method for class 'formula'
LdaPP(formula, data, subset, na.action, ...)

## Default S3 method:
LdaPP(x, grouping, prior = proportions, tol = 1.0e-4,
method = c("huber", "mad", "sest", "class"),
optim = FALSE,
trace=FALSE, ...)

Arguments

formula  a formula of the form y~x, it describes the response and the predictors. The formula can be more complicated, such as y~log(x)+z etc (see formula for more details). The response should be a factor representing the response variable, or any vector that can be coerced to such (such as a logical variable).

data  an optional data frame (or similar: see model.frame) containing the variables in the formula formula.
subset an optional vector used to select rows (observations) of the data matrix \( x \).

na.action a function which indicates what should happen when the data contain NAs. The default is set by the na.action setting of options, and is na.fail if that is unset. The default is na.omit.

\( x \) a matrix or data frame containing the explanatory variables (training set).

grouping grouping variable: a factor specifying the class for each observation.

prior prior probabilities, default to the class proportions for the training set.

tol tolerance

method method

optim whether to perform the approximation using the Nelder and Mead simplex method (see function optim() from package stats). Default is optim = FALSE.

trace whether to print intermediate results. Default is trace = FALSE.

... arguments passed to or from other methods.

Details

Currently the algorithm is implemented only for binary classification and in the following will be assumed that only two groups are present.

The PP algorithm searches for low-dimensional projections of higher-dimensional data where a projection index is maximized. Similar to the original Fisher’s proposal the squared standardized distance between the observations in the two groups is maximized. Instead of the sample univariate mean and standard deviation (\( \mu, \sigma \)) robust alternatives are used. These are selected through the argument method and can be one of

- huber the pair (\( \hat{T}, \hat{S} \)) are the robust M-estimates of location and scale
- mad (\( \hat{T}, \hat{S} \)) are the Median and the Median Absolute Deviation
- sest the pair (\( \hat{T}, \hat{S} \)) are the robust S-estimates of location and scale
- class (\( \hat{T}, \hat{S} \)) are the mean and the standard deviation.

The first approximation \( A_1 \) to the solution is obtained by investigating a finite number of candidate directions, the unit vectors defined by all pairs of points such that one belongs to the first group and the other to the second group. The found solution is stored in the slots raw.1df and raw.1dfconst.

The second approximation \( A_2 \) (optional) is performed by a numerical optimization algorithm using \( A_1 \) as initial solution. The Nelder and Mead method implemented in the function optim is applied. Whether this refinement will be used is controlled by the argument optim. If optim=TRUE the result of the optimization is stored into the slots 1df and 1dfconst. Otherwise these slots are set equal to raw.1df and raw.1dfconst.

Value

Returns an S4 object of class \texttt{LdaPP-class}.

Warning

Still an experimental version! Only binary classification is supported.
Author(s)
Valentin Todorov <valentin.todorov@chello.at> and Ana Pires <apires@math.ist.utl.pt>

References

See Also
Linda, LdaClassic

Examples

```R
## Function to plot a LDA separation line
##
## lda.line <- function(lda, ...)
## {
##   ab <- lda@ldf[1] - lda@ldf[2]
##   cc <- lda@ldfconst[1] - lda@ldfconst[2]
##   abline(a=-cc/ab[2], b=-ab[1]/ab[2],...)
## }

data(pottery)
x <- pottery[,c("MG", "CA")]
group <- pottery$origin
col <- c(3,4)
gcol <- ifelse(group == "Attic", col[1], col[2])
gpch <- ifelse(group == "Attic", 16, 1)

## Reproduce Fig. 2. from Pires and branco (2010)
##
## plot(CA~MG, data=pottery, col=gcol, pch=gpch)

ppc <- LdaPP(x, grp="class", optim=TRUE)
lda.line(ppc, col=1, lwd=2, lty=1)

pph <- LdaPP(x, grp="huber", optim=TRUE)
lda.line(pph, col=3, lty=3)

pps <- LdaPP(x, grp="sest", optim=TRUE)
lda.line(pps, col=4, lty=4)

ppm <- LdaPP(x, grp="mad", optim=TRUE)
lda.line(ppm, col=5, lty=5)

rlda <- Linda(x, grp, method="mcd")
lda.line(rlda, col=6, lty=1)
```
fsa <- Linda(x, grp, method="fsa")
lda.line(fsa, col=8, lty=6)

## Use the formula interface:
##
LdaPP(origin~MG+CA, data=pottery)       ## use the same two predictors
LdaPP(origin~, data=pottery)           ## use all predictor variables

##
## Predict method
data(pottery)
fit <- LdaPP(origin~, data = pottery)
predict(fit)

---

**Description**

The class `LdaPP` represents an algorithm for robust linear discriminant analysis by projection-pursuit approach. The objects of class `LdaPP` contain the results of the robust linear discriminant analysis by projection-pursuit approach.

**Objects from the Class**

Objects can be created by calls of the form `new("LdaPP", ...)` but the usual way of creating `LdaPP` objects is a call to the function `LdaPP` which serves as a constructor.

**Slots**

call: The (matched) function call.
prior: Prior probabilities used, default to group proportions
counts: number of observations in each class
center: the group means
cov: the common covariance matrix
raw.ldf: a matrix containing the raw linear discriminant functions - see Details in `LdaPP`
raw.ldfconst: a vector containing the raw constants of each raw linear discriminant function - see Details in `LdaPP`
ldf: a matrix containing the linear discriminant functions
ldfconst: a vector containing the constants of each linear discriminant function
method: a character string giving the estimation method used
X: the training data set (same as the input parameter x of the constructor function)
grp: grouping variable: a factor specifying the class for each observation.
**LdaRobust-class**

Extends  
Class "LdaRobust", directly. Class "Lda", by class "LdaRobust", distance 2.

Methods  
`predict` signature(object = "LdaPP"): calculates prediction using the results in object. An optional data frame or matrix in which to look for variables with which to predict. If omitted, the training data set is used. If the original fit used a formula or a data frame or a matrix with column names, newdata must contain columns with the same names. Otherwise it must contain the same number of columns, to be used in the same order. If the argument `raw=TRUE` is set the raw (obtained by the first approximation algorithm) linear discriminant function and constant will be used.

Author(s)  
Valentin Todorov <valentin.todorov@chello.at> and Ana Pires <apires@math.ist.utl.pt>

References  


See Also  
`LdaRobust-class`, `Lda-class`, `LdaClassic`, `LdaClassic-class`, `Linda`, `Linda-class`

Examples  
`showClass("LdaPP")`

---

**LdaRobust-class**  
Class "LdaRobust" is a virtual base class for all robust LDA classes

Description  
The class LdaRobust serves as a base class for deriving all other classes representing the results of the robust Linear Discriminant Analysis methods

Objects from the Class  
A virtual Class: No objects may be created from it.
**Slots**

- **call**: The (matched) function call.
- **prior**: Prior probabilities used, default to group proportions
- **counts**: number of observations in each class
- **center**: the group means
- **cov**: the common covariance matrix
- **ldf**: a matrix containing the linear discriminant functions
- **ldfconst**: a vector containing the constants of each linear discriminant function
- **method**: a character string giving the estimation method used
- **x**: the training data set (same as the input parameter x of the constructor function)
- **grp**: grouping variable: a factor specifying the class for each observation.

**Extends**

Class "Lda", directly.

**Methods**

No methods defined with class "LdaRobust" in the signature.

**Author(s)**

Valentin Todorov <valentin.todorov@chello.at>

**References**


**See Also**

- `lda-class`, `ldaClassic-class`

**Examples**

```r
showClass("LdaRobust")
```
### Description

Robust linear discriminant analysis based on MCD and returns the results as an object of class `Linda` (aka constructor).

### Usage

```r
Linda(x, ...)  
```

### Arguments

- **x**: a matrix or data frame containing the explanatory variables (training set).
- **grouping**: grouping variable: a factor specifying the class for each observation.
- **prior**: prior probabilities, default to the class proportions for the training set.
- **tol**: tolerance
- **method**: method
- **alpha**: this parameter measures the fraction of outliers the algorithm should resist. In MCD, alpha controls the size of the subsets over which the determinant is minimized, i.e. alpha*n observations are used for computing the determinant. Allowed values are between 0.5 and 1 and the default is 0.5.
- **l1med**: whether to use L1 median (space median) instead of MCD to compute the group means locations in order to center the data in methods mcdB and mcdC. useful in case of groups with small size. Default is l1med = FALSE.
- **trace**: whether to print intermediate results. Default is trace = FALSE.

### Details

- **Value**: Returns an S4 object of class `Linda`

### Warning

Still an experimental version!
Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

CovMcd

Examples

```r
## Example anorexia
library(MASS)
data(anorexia)

## start with the classical estimates
lda <- LdaClassic(Treat~., data=anorexia)
predict(lda)@classification

## try now the robust LDA with the default method (MCD with pooled within cov matrix)
rlda <- Linda(Treat~., data= anorexia)
predict(rlda)@classification

## try the other methods
Linda(Treat~., data= anorexia, method="mcdA")
Linda(Treat~., data= anorexia, method="mcdB")
Linda(Treat~., data= anorexia, method="mcdC")

## try the HawkinsMcLachlan method
## use the default method
gp <- anorexia[,1]
gp <- as.factor(gp)
x <- anorexia[,2:3]
Linda(x, gp, method="fsa")

## Do DA with Linda and method mcdB or mcdC, when some classes
## have very few observations. Use L1 median instead of MCD
## to compute the group means (l1med=TRUE).
data(fish)
```
Linda-class

# remove observation #14 containing missing value
fish <- fish[-14,]

# The height and width are calculated as percentages
# of the third length variable
fish[,5] <- fish[,5]*fish[,4]/100
fish[,6] <- fish[,6]*fish[,4]/100

table(fish$Species)
Linda(Species=-., data=fish, l1med=TRUE)
Linda(Species=-., data=fish, method="mcdC", l1med=TRUE)

---

**Description**

Robust linear discriminant analysis is performed by replacing the classical group means and within
group covariance matrix by robust equivalents based on MCD.

**Objects from the Class**

Objects can be created by calls of the form `new("Linda", ...)` but the usual way of creating
Linda objects is a call to the function Linda which serves as a constructor.

**Slots**

call: The (matched) function call.
prior: Prior probabilities used, default to group proportions
counts: number of observations in each class
center: the group means
cov: the common covariance matrix
ldf: a matrix containing the linear discriminant functions
ldfconst: a vector containing the constants of each linear discriminant function
method: a character string giving the estimation method used
X: the training data set (same as the input parameter x of the constructor function)
grp: grouping variable: a factor specifying the class for each observation.
l1med: whether L1 median was used to compute group means.

**Extends**

Class "LdaRobust", directly. Class "Lda", by class "LdaRobust", distance 2.
Methods
No methods defined with class "Linda" in the signature.

Author(s)
Valentin Todorov <valentin.todorov@chello.at>

References

See Also
LdaRobust-class, Lda-class, LdaClassic, LdaClassic-class

Examples
showClass("Linda")

---

### lmom32

*Hosking and Wallis Data Set, Table 3.2*

Description
The data on annual maximum streamflow at 18 sites with smallest drainage area basin in southeastern USA contains the sample L-moments ratios (L-CV, L-skewness and L-kurtosis) as used by Hosking and Wallis (1997) to illustrate the discordancy measure in regional frequency analysis (RFA).

Usage
data(lmom32)

Format
A data frame with 18 observations on the following 3 variables.

- L-CV  L-coefficient of variation
- L-skewness  L-coefficient of skewness
- L-kurtosis  L-coefficient of kurtosis

Details
The sample L-moment ratios (L-CV, L-skewness and L-kurtosis) of a site are regarded as a point in three dimensional space.
Source


References


Examples

data(lmom32)

# plot a matrix of scatterplots
pairs(lmom32,
     main="Hosking and Wallis Data Set, Table 3.3",
     pch=21,
     bg=c("red", "green3", "blue"))

mcd<-CovMcd(lmom32)

mcd

plot(mcd, which="dist", class=TRUE)
plot(mcd, which="dd", class=TRUE)

## identify the discordant sites using robust distances and compare
## to the classical ones
mcd <- CovMcd(lmom32)
rd <- sqrt(getDistance(mcd))
ccov <- CovClassic(lmom32)

cd <- sqrt(getDistance(ccov))

r.out <- which(rd > sqrt(qchisq(0.975,3)))
c.out <- which(cd > sqrt(qchisq(0.975,3)))

cat("Robust: ", length(r.out), " outliers: ", r.out,\\n")
cat("Classical: ", length(c.out), " outliers: ", c.out,\\n")

---

**Hosking and Wallis Data Set, Table 3.3**

Description

The data on annual maximum streamflow at 17 sites with largest drainage area basins in southeastern USA contains the sample L-moments ratios (L-CV, L-skewness and L-kurtosis) as used by Hosking and Wallis (1997) to illustrate the discordancy measure in regional frequency analysis (RFA).

Usage

data(lmom33)
A data frame with 17 observations on the following 3 variables.

L-CV  L-coefficient of variation
L-skewness  L-coefficient of skewness
L-kurtosis  L-coefficient of kurtosis

The sample L-moment ratios (L-CV, L-skewness and L-kurtosis) of a site are regarded as a point in three dimensional space.


```
data(lmom33)

# plot a matrix of scatterplots
pairs(lmom33,
     main="Hosking and Wallis Data Set, Table 3.3",
     pch=21,
     bg=c("red", "green3", "blue"))

mcd<-CovMcd(lmom33)
mcd
plot(mcd, which="dist", class=TRUE)
plot(mcd, which="dd", class=TRUE)

## identify the discordant sites using robust distances and compare
## to the classical ones
mcd <- CovMcd(lmom33)
r <- sqrt(getDistance(mcd))
cov <- CovClassic(lmom33)
cd <- sqrt(getDistance(cov))
r.out <- which(r > sqrt(qchisq(0.975,3)))
c.out <- which(c > sqrt(qchisq(0.975,3)))
cat("Robust: ", length(r.out), " outliers: ", r.out, "\n")
cat("Classical: ", length(c.out), " outliers: ", c.out,"\n")
```
**Description**

Simple artificial data set generated according the example by Marona and Yohai (1998). The data set consists of 20 bivariate normal observations generated with zero means, unit variances and correlation 0.8. The sample correlation is 0.81. Two outliers are introduced (i.e. these are 10% of the data) in the following way: two points are modified by interchanging the largest (observation 19) and smallest (observation 9) value of the first coordinate. The sample correlation becomes 0.05. This example provides a good example of the fact that a multivariate outlier need not be an outlier in any of its coordinate variables.

**Usage**

```r
data(maryo)
```

**Format**

A data frame with 20 observations on 2 variables. To introduce the outliers x[9,1] with x[19,1] are interchanged.

**Source**


**Examples**

```r
data(maryo)
getcorr(covclassic(maryo))  ## the sample correlation is 0.81

## Modify 10% of the data in the following way:
## modify two points (out of 20) by interchanging the
## largest and smallest value of the first coordinate
imin <- which(maryo[,1]==min(maryo[,1]))  # imin = 9
imax <- which(maryo[,1]==max(maryo[,1]))  # imax = 19
maryo[imin,1] <- maryo[imax,1]
maryo[imax,1] <- maryo[imin,1]

## The sample correlation becomes 0.05
plot(maryo)
getcorr(covclassic(maryo))  ## the sample correlation becomes 0.05
getcorr(covmcd(maryo))  ## the (rewighted) MCD correlation is 0.79
```
Description

The oslo Transect data set contains 360 samples of different plant species collected along a 120 km transect running through the city of Oslo, Norway.

Usage

data(Oslo Transect)

Format

A data frame with 360 observations on the following 38 variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>xID</td>
<td>a numeric vector, unique ID of the sample</td>
</tr>
<tr>
<td>xMAT</td>
<td>a factor with levels BBA BIL BWO FER MOS ROG SNE STW TWI</td>
</tr>
<tr>
<td>xCOO</td>
<td>a numeric vector, X coordinate</td>
</tr>
<tr>
<td>yCOO</td>
<td>a numeric vector, Y coordinate</td>
</tr>
<tr>
<td>xCOO_km</td>
<td>a numeric vector</td>
</tr>
<tr>
<td>yCOO_km</td>
<td>a numeric vector</td>
</tr>
<tr>
<td>xFOREST</td>
<td>a factor with levels BIRSPR MIXDEC PINE SPRBIR SPRPIN SPRUCE</td>
</tr>
<tr>
<td>DAY</td>
<td>a numeric vector</td>
</tr>
<tr>
<td>xWEATHER</td>
<td>a factor with levels CLOUD MOIST NICE RAIN</td>
</tr>
<tr>
<td>ALT</td>
<td>a numeric vector</td>
</tr>
<tr>
<td>xASP</td>
<td>a factor with levels E FLAT N NE NW S SE SW W</td>
</tr>
<tr>
<td>xGRVEG</td>
<td>a factor with levels BLGR BLLY BLMLOLI BLUE BLUGRA GRAS GRBLU GRFE GRMO LYLI MIX MOGR MOSS</td>
</tr>
<tr>
<td>xFLITHO</td>
<td>a factor with levels CAMSED GNEID_0 GNEIS_0 GNEIS_R MAGM MICSH</td>
</tr>
<tr>
<td>Ag_ppb</td>
<td>a numeric vector</td>
</tr>
<tr>
<td>As_ash</td>
<td>a numeric vector</td>
</tr>
<tr>
<td>B</td>
<td>a numeric vector</td>
</tr>
<tr>
<td>Ba</td>
<td>a numeric vector</td>
</tr>
<tr>
<td>Ca</td>
<td>a numeric vector</td>
</tr>
<tr>
<td>Cd</td>
<td>a numeric vector</td>
</tr>
<tr>
<td>Co</td>
<td>a numeric vector</td>
</tr>
<tr>
<td>Cr</td>
<td>a numeric vector</td>
</tr>
<tr>
<td>Cu</td>
<td>a numeric vector</td>
</tr>
<tr>
<td>Fe</td>
<td>a numeric vector</td>
</tr>
</tbody>
</table>
OsloTransect

Hg_ppb a numeric vector
K a numeric vector
La a numeric vector
LOI a numeric vector
Mg a numeric vector
Mn a numeric vector
Mo a numeric vector
Ni a numeric vector
P a numeric vector
Pb a numeric vector
S a numeric vector
Sb a numeric vector
Sr a numeric vector
Ti a numeric vector
Zn a numeric vector

Details

Samples of different plant species were collected along a 120 km transect running through the city of Oslo, Norway (forty samples each of leaves, needles, roots or barks of several plant species), and the concentrations of 25 chemical elements for the sample materials are reported. The factors that influenced the observed element concentrations in the sample materials were investigated. This data set was used in Todorov and Filzmoser (2007) for illustration of the robust statistics for one-way MANOVA implemented in the function Wilks.test.

Source


References

Examples

```r
data(OsloTransect)
str(OsloTransect)

##
## Log-transform the numerical part of the data, choose the desired groups and variables and perform the classical Wilks' Lambda test
##
OsloTransect[,14:38] <- log(OsloTransect[,14:38])
grp <- OsloTransect$X.FLITHO
ind <- which(grp == "CAMSED" | grp == "GNEIS_O" | grp == "GNEIS_R" | grp == "MAGM")
(cwl <- Wilks.test(X.FLITHO*K+P+Zn+Cu,data=OsloTransect[ind,]))

##
## Perform now the robust MCD based Wilks' Lambda test. Use the already computed multiplication factor 'xd' and degrees of freedom 'xq' for the approximate distribution.
##
xd <- -0.003708238
xq <- 11.79073
(mcdwl <- Wilks.test(X.FLITHO*K+P+Zn+Cu,data=OsloTransect[ind,], method="mcd", xd=xd, xq=xq))
```

Pca-class

Class "Pca" - virtual base class for all classic and robust PCA classes

Description

The class Pca serves as a base class for deriving all other classes representing the results of the classical and robust Principal Component Analysis methods.

Objects from the Class

A virtual Class: No objects may be created from it.

Slots

call: Object of class "language"
center: Object of class "vector" the center of the data
scale: Object of class "vector" the scaling applied to each variable of the data
loadings: Object of class "matrix" the matrix of variable loadings (i.e., a matrix whose columns contain the eigenvectors)
eigenvalues: Object of class "vector" the eigenvalues
Pca-class

scores: Object of class "matrix" the scores - the value of the projected on the space of the principal components data (the centred (and scaled if requested) data multiplied by the loadings matrix) is returned. Hence, cov(scores) is the diagonal matrix diag(eigenvalues)

k: Object of class "numeric" number of (chosen) principal components

sd: Object of class "vector" Score distances within the robust PCA subspace

od: Object of class "vector" Orthogonal distances to the robust PCA subspace

cutoff.sd: Object of class "numeric" Cutoff value for the score distances

cutoff.od: Object of class "numeric" Cutoff values for the orthogonal distances

flag: Object of class "vector" The observations whose score distance is larger than cutoff.sd or whose orthogonal distance is larger than cutoff.od can be considered as outliers and receive a flag equal to zero. The regular observations receive a flag 1

crit.pca.distances criterion to use for computing the cutoff values for the orthogonal and score distances. Default is 0.975.

n.obs: Object of class "numeric" the number of observations

Methods

getCenter signature(obj = "Pca"): center of the data

getScale signature(obj = "Pca"): return the scaling applied to each variable

gETEigenvalues signature(obj = "Pca"): the eigenvalues of the covariance/correlation matrix, though the calculation is actually done with the singular values of the data matrix

gEIgLoadings signature(obj = "Pca"): returns the matrix loadings (i.e., a matrix whose columns contain the eigenvectors). The function prcomp returns this matrix in the element rotation.

getPrcomp signature(obj = "Pca"): returns an S3 object prcomp for compatibility with the functions prcomp() and princomp(). Thus the standard plots screeplot() and biplot() can be used

getScores signature(obj = "Pca"): returns the rotated data (the centred (and scaled if requested) data multiplied by the loadings matrix).

gETSDev signature(obj = "Pca"): returns the standard deviations of the principal components (i.e., the square roots of the eigenvalues of the covariance/correlation matrix, though the calculation is actually done with the singular values of the data matrix)

plot signature(x = "Pca"): produces a distance plot (if k=rank) or distance-distance plot (if k<rank)

print signature(x = "Pca"): prints the results. The difference to the show() method is that additional parameters are possible.

show signature(object = "Pca"): prints the results

predict signature(object = "Pca"): calculates prediction using the results in object. An optional data frame or matrix in which to look for variables with which to predict. If omitted, the scores are used. If the original fit used a formula or a data frame or a matrix with column names, newdata must contain columns with the same names. Otherwise it must contain the same number of columns, to be used in the same order. See also predict.prcomp and predict.princomp

screepplot signature(x = "Pca"): plots the variances against the number of the principal component. See also plot.prcomp and plot.princomp
**pca.distances**

**Author(s)**

Valentin Todorov <valentin.todorov@chello.at>

**References**


**See Also**

PcaClassic, PcaClassic-class, PcaRobust-class

**Examples**

```r
showClass("Pca")
```

---

**pca.distances**  
*Compute score and orthogonal distances for Principal Components (objects of class `Pca`)*

**Description**

Compute score and orthogonal distances for an object (derived from) Pca-class.

**Usage**

```r
pca.distances(obj, data, r, crit=0.975)
```

**Arguments**

- `obj`  
an object of class (derived from) "Pca".
- `data`  
The data matrix for which the "Pca" object was computed.
- `r`  
rank of data
- `crit`  
Criterion to use for computing the cutoff values.

**Details**

This function calculates the score and orthogonal distances and the appropriate cutoff values for identifying outlying observations. The computed values are used to create a vector a of flags, one for each observation, identifying the outliers.

**Value**

An S4 object of class derived from the virtual class Pca-class - the same object passed to the function, but with the score and orthogonal distances as well as their cutoff values and the corresponding flags appended to it.
Author(s)
Valentin Todorov <valentin.todorov@chello.at>

References
M. Hubert, P. J. Rousseeuw, K. Vanden Branden (2005), ROBPCA: a new approach to robust principal components analysis, Technometrics, 47, 64–79.

Examples

```r
## PCA of the Hawkins Bradu Kass's Artificial Data
## using all 4 variables
data(hbk)
pca <- PcaHubert(hbk)
pca.distances(pca, hbk, rankMM(hbk))
```

pca.scoreplot                  Score plot for Principal Components (objects of class 'Pca')

Description

Produces a score plot from an object (derived from) **Pca-class**.

Usage

```r
pca.scoreplot(obj, i=1, j=2, main, id.n=0, ...)
```

Arguments

- `obj` an object of class (derived from) "Pca".
- `i` First score coordinate, defaults to i=1.
- `j` Second score coordinate, defaults to j=2.
- `main` The main title of the plot.
- `id.n` Number of observations to identify by a label. Defaults to id.n=0.
- `...` optional arguments to be passed to the internal graphical functions.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

See Also

**Pca-class, PcaClassic, PcaRobust-class.**
Examples

```r
require(graphics)

## PCA of the Hawkins Bradu Kass's Artificial Data
## using all 4 variables
data(hbk)
pca <- PcaHubert(hbk)
pca
pca.scoreplot(pca)
```

---

**PcaClassic**

*Principal Components Analysis*

**Description**

Performs a principal components analysis and returns the results as an object of class PcaClassic (aka constructor).

**Usage**

```r
PcaClassic(x, ...) 
# Default S3 method:
PcaClassic(x, k = ncol(x), kmax = ncol(x), 
    scale=FALSE, signflip=TRUE, crit.pca.distances = 0.975, trace=FALSE, ...)
# S3 method for class 'formula'
PcaClassic(formula, data = NULL, subset, na.action, ...)
```

**Arguments**

- `formula`: a formula with no response variable, referring only to numeric variables.
- `data`: an optional data frame (or similar: see `model.frame`) containing the variables in the formula `formula`.
- `subset`: an optional vector used to select rows (observations) of the data matrix `x`.
- `na.action`: a function which indicates what should happen when the data contain NAs. The default is set by the `na.action` setting of `options`, and is `na.fail` if that is unset. The default is `na.omit`.
- `...`: arguments passed to or from other methods.
- `x`: a numeric matrix (or data frame) which provides the data for the principal components analysis.
- `k`: number of principal components to compute. If `k` is missing, or `k = 0`, the algorithm itself will determine the number of components by finding such `k` that $l_k/l_1 \geq 10^{-3}$ and $\Sigma_j=l_j/\Sigma_j = 0.8$. It is preferable to investigate the scree plot in order to choose the number of components and then run again. Default is `k=ncol(x)`.
- `kmax`: maximal number of principal components to compute. Default is `kmax=10`. If `k` is provided, `kmax` does not need to be specified, unless `k` is larger than 10.
scale

A value indicating whether and how the variables should be scaled to have unit variance (only possible if there are no constant variables). If scale=FALSE (default) or scale=NULL no scaling is performed (a vector of 1s is returned in the scale slot). If scale=TRUE the data are scaled to have unit variance. Alternatively it can be a function like sd or Qn or a vector of length equal the number of columns of x. The value is passed to the underlying function and the result returned is stored in the scale slot. Default is scale=FALSE.

signflip

A logical value indicating whether to try to solve the sign indeterminacy of the loadings - ad hoc approach setting the maximum element in a singular vector to be positive. Default is signflip = FALSE.

crit.pca.distances

criterion to use for computing the cutoff values for the orthogonal and score distances. Default is 0.975.

trace

Whether to print intermediate results. Default is trace = FALSE.

Value

An S4 object of class PcaClassic-class which is a subclass of the virtual class Pca-class.

Note

This function can be seen as a wrapper around prcomp() from stats which returns the results of the PCA in a class compatible with the object model for robust PCA.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

Pca-class, PcaClassic-class.

---

PcaClassic-class \hspace{1cm} Class "PcaClassic" - Principal Components Analysis

Description

Contains the results of a classical Principal Components Analysis

Objects from the Class

Objects can be created by calls of the form new("PcaClassic", ...) but the usual way of creating PcaClassic objects is a call to the function PcaClassic which serves as a constructor.
Slots

- **call**: Object of class "language"
- **center**: Object of class "vector" the center of the data
- **scale**: Object of class "vector" the scaling applied to each variable
- **loadings**: Object of class "matrix" the matrix of variable loadings (i.e., a matrix whose columns contain the eigenvectors)
- **eigenvalues**: Object of class "vector" the eigenvalues
- **scores**: Object of class "matrix" the scores - the value of the projected on the space of the principal components data (the centred (and scaled if requested) data multiplied by the loadings matrix) is returned. Hence, cov(scores) is the diagonal matrix diag(eigenvalues)
- **k**: Object of class "numeric" number of (chosen) principal components
- **sd**: Object of class "Uvector" Score distances within the robust PCA subspace
- **od**: Object of class "Uvector" Orthogonal distances to the robust PCA subspace
- **cutoff.sd**: Object of class "numeric" Cutoff value for the score distances
- **cutoff.od**: Object of class "numeric" Cutoff values for the orthogonal distances
- **flag**: Object of class "Uvector" The observations whose score distance is larger than cutoff.sd or whose orthogonal distance is larger than cutoff.od can be considered as outliers and receive a flag equal to zero. The regular observations receive a flag 1
- **n.obs**: Object of class "numeric" the number of observations

Extends

Class "Pca", directly.

Methods

- **getQuan** signature(obj = "PcaClassic"): returns the number of observations used in the computation, i.e. n.obs

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

PcaRobust-class, Pca-class, PcaClassic

Examples

showClass("PcaClassic")
PcaCov

Robust PCA based on a robust covariance matrix

Description

Robust PCA are obtained by replacing the classical covariance matrix by a robust covariance estimator. This can be one of the available in rrcov estimators, i.e. MCD, OGK, M or S estimator.

Usage

PcaCov(x, ...)  
## Default S3 method:  
PcaCov(x, k = ncol(x), kmax = ncol(x), cov.control=CovControlMcd(),  
    scale = FALSE, signflip = TRUE, crit.pca.distances = 0.975, trace=FALSE, ...)  
## S3 method for class 'formula'  
PcaCov(formula, data = NULL, subset, na.action, ...)

Arguments

formula a formula with no response variable, referring only to numeric variables.
data an optional data frame (or similar: see model.frame) containing the variables in the formula formula.
subset an optional vector used to select rows (observations) of the data matrix x.
na.action a function which indicates what should happen when the data contain NAs. The default is set by the na.action setting of options, and is na.fail if that is unset. The default is na.omit.
... arguments passed to or from other methods.
x a numeric matrix (or data frame) which provides the data for the principal components analysis.
k number of principal components to compute. If k is missing, or k = 0, the algorithm itself will determine the number of components by finding such k that \( l_k/l_1 \geq 10.7E-3 \) and \( \sum_{j=1}^{k} l_j / \sum_{j=1}^{r} l_j \geq 0.8 \). It is preferable to investigate the scree plot in order to choose the number of components and then run again. Default is k=ncol(x).
kmax maximal number of principal components to compute. Default is kmax=10. If k is provided, kmax does not need to be specified, unless k is larger than 10.
cov.control specifies which covariance estimator to use by providing a CovControl-class object. The default is CovControlMcd-class which will indirectly call CovMcd. If cov.control=NULL is specified, the classical estimates will be used by calling CovClassic.
scale a value indicating whether and how the variables should be scaled to have unit variance (only possible if there are no constant variables). If scale=FALSE (default) or scale=NULL no scaling is performed (a vector of 1s is returned in the scale slot). If scale=TRUE the data are scaled by the estimator used to compute...
the covariance matrix (MCD by default). Alternatively it can be a function like
sd or Qn or a vector of length equal the number of columns of x. The value is
passed to the underlying function and the result returned is stored in the scale
slot. Default is scale=FALSE.

signflip  

a logical value indicating wheather to try to solve the sign indeterminancy of the
loadings - ad hoc approach setting the maximum element in a singular vector to
be positive. Default is signflip = FALSE.

crit.pca.distances  
criterion to use for computing the cutoff values for the orthogonal and score
distances. Default is 0.975.

trace  

whether to print intermediate results. Default is trace = FALSE

Details

PcaCov, serving as a constructor for objects of class PcaCov-class is a generic function with
"formula" and "default" methods. For details see the relevant references.

Value

An S4 object of class PcaCov-class which is a subclass of the virtual class PcaRobust-class.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


Examples

```r
## PCA of the Hawkins Bradu Kass's Artificial Data
## using all 4 variables
data(hbk)
pca <- PcaCov(hbk)
pca

## Compare with the classical PCA
prcomp(hbk)

## or
PcaClassic(hbk)

## If you want to print the scores too, use
print(pca, print.x=TRUE)

## Using the formula interface
PcaCov(~ ., data=hbk)
```
## To plot the results:

```r
plot(pca)  # distance plot
pca2 <- PcaCov(hbk, k=2)
plot(pca2)  # PCA diagnostic plot (or outlier map)
```

## Use the standard plots available for for prcomp and princomp

```r
screeplot(pca)
biplot(pca)
```

---

### PcaCov-class

**Class "PcaCov" - Robust PCA based on a robust covariance matrix**

#### Description

Robust PCA are obtained by replacing the classical covariance matrix by a robust covariance estimator. This can be one of the available in rrcov estimators, i.e. MCD, OGK, M, S or Stahel-Donoho estimator.

#### Objects from the Class

Objects can be created by calls of the form `new("PcaCov", ...)` but the usual way of creating PcaCov objects is a call to the function `PcaCov` which serves as a constructor.

#### Slots

- `quan`: Object of class "numeric" The quantile h used throughout the algorithm
- `call`, `center`, `loadings`, `eigenvalues`, `scores`, `k`, `sd`, `od`, `cutoff.sd`, `cutoff.od`, `flag`, `n.obs`: from the "Pca" class.

#### Extends

Class "PcaRobust", directly. Class "Pca", by class "PcaRobust", distance 2.

#### Methods

- `getQuan` signature(obj = "PcaCov"): ...

#### Author(s)

Valentin Todorov <valentin.todorov@chello.at>

#### References

**See Also**

`PcaRobust-class, Pca-class, PcaClassic, PcaClassic-class`

**Examples**

```r
showClass("PcaCov")
```

---

**PcaGrid**

Robust Principal Components based on Projection Pursuit (PP):
GRID search Algorithm

**Description**

Computes an approximation of the PP-estimators for PCA using the grid search algorithm in the plane.

**Usage**

```r
PcaGrid(x, ...)  
## Default S3 method: 
PcaGrid(x, k = 0, kmax = ncol(x),  
scale = FALSE, na.action = na.fail, crit.pca.distances = 0.975, trace = FALSE, ...)  
## S3 method for class 'formula' 
PcaGrid(formula, data = NULL, subset, na.action, ...)
```

**Arguments**

- `formula`: a formula with no response variable, referring only to numeric variables.
- `data`: an optional data frame (or similar: see `model.frame`) containing the variables in the formula `formula`.
- `subset`: an optional vector used to select rows (observations) of the data matrix `x`.
- `na.action`: a function which indicates what should happen when the data contain NAs. The default is set by the `na.action` setting of `options`, and is `na.fail` if that is unset. The default is `na.omit`.
- `...`: arguments passed to or from other methods.
- `x`: a numeric matrix (or data frame) which provides the data for the principal components analysis.
- `k`: number of principal components to compute. If `k` is missing, or `k = 0`, it is set to the number of columns of the data. It is preferable to investigate the scree plot in order to choose the number of components and then run again. Default is `k=0`.
- `kmax`: maximal number of principal components to compute. Default is `kmax=10`. If `k` is provided, `kmax` does not need to be specified, unless `k` is larger than 10.
scale a value indicating whether and how the variables should be scaled. If \texttt{scale} = \texttt{FALSE}
(default) or \texttt{scale} = \texttt{NULL} no scaling is performed (a vector of 1s is returned in the \texttt{scale} slot). If \texttt{scale} = \texttt{TRUE} the data are scaled to have unit variance. Alternatively it can be a function like \texttt{sd} or \texttt{mad} or a vector of length equal the number of columns of \texttt{x}. The value is passed to the underlying function and the result returned is stored in the \texttt{scale} slot. Default is \texttt{scale} = \texttt{FALSE}

crit.pca.distances criterion to use for computing the cutoff values for the orthogonal and score distances. Default is 0.975.

trace whether to print intermediate results. Default is \texttt{trace} = \texttt{FALSE}

Details

PcaGrid, serving as a constructor for objects of class \texttt{PcaGrid-class} is a generic function with "formula" and "default" methods. For details see \texttt{PCAggrid} and the relevant references.

Value

An S4 object of class \texttt{PcaGrid-class} which is a subclass of the virtual class \texttt{PcaRobust-class}.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


Examples

```r
# multivariate data with outliers
library(mvtnorm)
x <- rbind(rmvnorm(200, rep(0, 6), diag(c(5, rep(1,5)))),
           rmvnorm(15, c(0, rep(20, 5)), diag(rep(1, 6))))
# Here we calculate the principal components with PCAggrid
pc <- PcaGrid(x, 6)
# we could draw a biplot too:
biplot(pc)

# we could use another objective function, and
# maybe only calculate the first three principal components:
pc <- PcaGrid(x, 3, method="qn")
biplot(pc)

# now we want to compare the results with the non-robust principal components
pc <- PcaClassic(x, k=3)
# again, a biplot for comparision:
biplot(pc)
```
Class "PcaGrid" - Robust PCA using PP - GRID search Algorithm

Description

Holds the results of an approximation of the PP-estimators for PCA using the grid search algorithm in the plane.

Objects from the Class

Objects can be created by calls of the form new("PcaGrid", ...) but the usual way of creating PcaGrid objects is a call to the function PcaGrid() which serves as a constructor.

Slots

call, center, scale, loadings, eigenvalues, scores, k, sd, od, cutoff.sd, cutoff.od, flag, n.obs: from the "Pca" class.

Extends

Class "PcaRobust", directly. Class "Pca", by class "PcaRobust", distance 2.

Methods

getQuan signature(obj = "PcaGrid"): ...

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

PcaRobust-class, Pca-class, PcaClassic, PcaClassic-class

Examples

showClass("PcaGrid")
Description

The ROBPCA algorithm was proposed by Hubert et al (2005) and stays for 'ROBust method for Principal Components Analysis'. It is resistant to outliers in the data. The robust loadings are computed using projection-pursuit techniques and the MCD method. Therefore ROBPCA can be applied to both low and high-dimensional data sets. In low dimensions, the MCD method is applied.

Usage

PcaHubert(x, ...)  
## Default S3 method: 
PcaHubert(x, k = 0, kmax = 10, alpha = 0.75, mcd = TRUE,  
maxdir=250, scale = FALSE, signflip = TRUE, crit.pca.distances = 0.975, trace=FALSE, ...)  
## S3 method for class 'formula' 
PcaHubert(formula, data = NULL, subset, na.action, ...)

Arguments

- **formula**: a formula with no response variable, referring only to numeric variables.
- **data**: an optional data frame (or similar: see model.frame) containing the variables in the formula formula.
- **subset**: an optional vector used to select rows (observations) of the data matrix x.
- **na.action**: a function which indicates what should happen when the data contain NAs. The default is set by the na.action setting of options, and is na.fail if that is unset. The default is na.omit.
- **...**: arguments passed to or from other methods.
- **x**: a numeric matrix (or data frame) which provides the data for the principal components analysis.
- **k**: number of principal components to compute. If k is missing, or k = 0, the algorithm itself will determine the number of components by finding such k that $l_k / l_1 \geq 10^E - 3$ and $\sum_{j=1}^{k} l_j / \sum_{j=1}^{r} l_j \geq 0.8$. It is preferable to investigate the scree plot in order to choose the number of components and then run again. Default is k=0.
- **kmax**: maximal number of principal components to compute. Default is kmax=10. If k is provided, kmax does not need to be specified, unless k is larger than 10.
- **alpha**: this parameter measures the fraction of outliers the algorithm should resist. In MCD alpha controls the size of the subsets over which the determinant is minimized, i.e. alpha*n observations are used for computing the determinant. Allowed values are between 0.5 and 1 and the default is 0.75.
Logical - when the number of variables is sufficiently small, the loadings are computed as the eigenvectors of the MCD covariance matrix, hence the function CovMcd() is automatically called. The number of principal components is then taken as \( k = \text{rank}(x) \). Default is mcd=TRUE. If mcd=FALSE, the ROBPCA algorithm is always applied.

maxdir maximal number of random directions to use for computing the outlyingness of the data points. Default is maxdir=250. If the number \( n \) of observations is small all possible \( n \times (n-1)/2 \) pairs of observations are taken to generate the directions.

scale a value indicating whether and how the variables should be scaled. If scale=FALSE (default) or scale=NULL no scaling is performed (a vector of 1s is returned in the scale slot). If scale=TRUE the data are scaled to have unit variance. Alternatively it can be a function like sd or mad or a vector of length equal the number of columns of \( x \). The value is passed to the underlying function and the result returned is stored in the scale slot. Default is scale=FALSE.

signflip a logical value indicating whether to try to solve the sign indeterminancy of the loadings - ad hoc approach setting the maximum element in a singular vector to be positive. Default is signflip = FALSE

crit.pca.distances criterion to use for computing the cutoff values for the orthogonal and score distances. Default is 0.975.

trace whether to print intermediate results. Default is trace = FALSE

Details

PcaHubert, serving as a constructor for objects of class PcaHubert-class is a generic function with "formula" and "default" methods. The calculation is done using the ROBPCA method of Hubert et al (2005) which can be described briefly as follows. For details see the relevant references.

Let \( n \) denote the number of observations, and \( p \) the number of original variables in the input data matrix \( X \). The ROBPCA algorithm finds a robust center \( M \) \((p \times 1)\) of the data and a loading matrix \( P \) which is \((p \times k)\) dimensional. Its columns are orthogonal and define a new coordinate system. The scores \( T \), an \((n \times k)\) matrix, are the coordinates of the centered observations with respect to the loadings:

\[
T = (X - M)P
\]

The ROBPCA algorithm also yields a robust covariance matrix (often singular) which can be computed as

\[
S = PP^T
\]

where \( L \) is the diagonal matrix with the eigenvalues \( l_1, \ldots, k \).

This is done in the following three main steps:

**Step 1**: The data are preprocessed by reducing their data space to the subspace spanned by the \( n \) observations. This is done by singular value decomposition of the input data matrix. As a result the data are represented using at most \( n-1=\text{rank}(X) \) without loss of information.

**Step 2**: In this step for each data point a measure of outlyingness is computed. For this purpose the high-dimensional data points are projected on many univariate directions, each time the univariate
MCD estimator of location and scale is computed and the standardized distance to the center is measured. The largest of these distances (over all considered directions) is the outlyingness measure of the data point. The h data points with smallest outlyingness measure are used to compute the covariance matrix $\Sigma_h$ and to select the number k of principal components to retain. This is done by finding such k that $l_k/l_1 > 10. E - 3$ and $\Sigma^k_{j=1} l_j / \Sigma^r_{j=1} l_j >= 0.8$ Alternatively the number of principal components k can be specified by the user after inspecting the scree plot.

Step 3: The data points are projected on the k-dimensional subspace spanned by the k eigenvectors corresponding to the largest k eigenvalues of the matrix $\Sigma_h$. The location and scatter of the projected data are computed using the reweighted MCD estimator and the eigenvectors of this scatter matrix yield the robust principal components.

Value

An S4 object of class PcaHubert-class which is a subclass of the virtual class PcaRobust-class.

Note

The ROBPCA algorithm is implemented on the bases of the Matlab implementation, available as part of LIBRA, a Matlab Library for Robust Analysis to be found at www.wis.kuleuven.ac.be/stat/robust.html

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References

M. Hubert, P. J. Rousseeuw, K. Vanden Branden (2005), ROBPCA: a new approach to robust principal components analysis, Technometrics, 47, 64–79.


Examples

```r
## PCA of the Hawkins Bradu Kass's Artificial Data
## using all 4 variables
data(hbk)
pca <- PcaHubert(hbk)
pca

## Compare with the classical PCA
prcomp(hbk)

## or
PcaClassic(hbk)

## If you want to print the scores too, use
print(pca, print.x=TRUE)

## Using the formula interface
PcaHubert(~., data=hbk)
```
## PcaHubert-class

Class "PcaHubert" - ROBust method for Principal Components Analysis

### Description

The ROBPCA algorithm was proposed by Hubert et al (2005) and stays for 'ROBust method for Principal Components Analysis'. It is resistant to outliers in the data. The robust loadings are computed using projection-pursuit techniques and the MCD method. Therefore ROBPCA can be applied to both low and high-dimensional data sets. In low dimensions, the MCD method is applied.

### Objects from the Class

Objects can be created by calls of the form new("PcaHubert", ...) but the usual way of creating PcaHubert objects is a call to the function PcaHubert which serves as a constructor.

### Slots

- **alpha**: Object of class "numeric" the fraction of outliers the algorithm should resist - this is the argument alpha
- **quan**: Object of class "numeric" The quantile h used throughout the algorithm
- **call, center, loadings, eigenvalues, scores, k, sd, od, cutoff.sd, cutoff.od, flag, n.obs**: from the "Pca" class.

### Extends

Class "PcaRobust", directly. Class "Pca", by class "PcaRobust", distance 2.

### Methods

- **getQuan** signature(obj = "PcaHubert"): Returns the quantile used throughout the algorithm
**Description**

The Spherical Principal Components procedure was proposed by Locantore et al., (1999) as a functional data analysis method. The idea is to perform classical PCA on the data, projected onto a unit sphere. The estimates of the eigenvectors are consistent and the procedure is extremely fast. The simulations of Maronna (2005) show that this method has very good performance.

**Usage**

```r
PcaLocantore(x, ...)  
## Default S3 method:  
PcaLocantore(x, k = ncol(x), kmax = ncol(x), delta = 0.001,  
    na.action = na.fail, scale = FALSE, signflip = TRUE,  
    crit.pca.distances = 0.975, trace=FALSE, ...)  
## S3 method for class 'formula'  
PcaLocantore(formula, data = NULL, subset, na.action, ...)  
```

**Arguments**

- `formula` a formula with no response variable, referring only to numeric variables.
- `data` an optional data frame (or similar: see `model.frame`) containing the variables in the formula `formula`.
- `subset` an optional vector used to select rows (observations) of the data matrix `x`.
- `na.action` a function which indicates what should happen when the data contain NAs. The default is set by the `na.action` setting of `options`, and is `na.fail` if that is unset. The default is `na.omit`.
- `...` arguments passed to or from other methods.
x a numeric matrix (or data frame) which provides the data for the principal components analysis.

k number of principal components to compute. If k is missing, or k = 0, the algorithm itself will determine the number of components by finding such k that \( l_k / l_1 \geq 10\epsilon - 3 \) and \( \sum_{j=1}^{k} l_j / \sum_{j=1}^{r} l_j \geq 0.8 \). It is preferable to investigate the scree plot in order to choose the number of components and then run again. Default is k = ncol(x).

kmax maximal number of principal components to compute. Default is kmax = 10. If k is provided, kmax does not need to be specified, unless k is larger than 10.

delta an accuracy parameter

scale a value indicating whether and how the variables should be scaled to have unit variance (only possible if there are no constant variables). If scale = FALSE (default) or scale = NULL no scaling is performed (a vector of 1s is returned in the scale slot). If scale = TRUE the data are scaled by mad. Alternatively it can be a function like sd or qn or a vector of length equal the number of columns of x. The value is passed to the underlying function and the result returned is stored in the scale slot. Default is scale = FALSE.

signflip a logical value indicating whether to try to solve the sign indeterminancy of the loadings - ad hoc approach setting the maximum element in a singular vector to be positive. Default is signflip = FALSE

crit.pca.distances criterion to use for computing the cutoff values for the orthogonal and score distances. Default is 0.975.

trace whether to print intermediate results. Default is trace = FALSE

Details

PcaLocantore, serving as a constructor for objects of class PcaLocantore-class is a generic function with "formula" and "default" methods. For details see the relevant references.

Value

An S4 object of class PcaLocantore-class which is a subclass of the virtual class PcaRobust-class.

Author(s)

Valentin Todorov <valentin.todorov@chello.at> The SPC algorithm is implemented on the bases of the available from the web site of the book Maronna et al. (2006) code http://www.wiley.com/legacy/wileychi/robust_statistics/

References


Examples

```r
## PCA of the Hawkins Bradu Kass's Artificial Data
## using all 4 variables
data(hbk)
pca <- PcaLocantore(hbk)
pca

## Compare with the classical PCA
prcomp(hbk)

## or
PcaClassic(hbk)

## If you want to print the scores too, use
print(pca, print.x=TRUE)

## Using the formula interface
PcaLocantore(~., data=hbk)

## To plot the results:
plot(pca)  # distance plot
cpa2 <- PcaLocantore(hbk, k=2)
plot(pca2)  # PCA diagnostic plot (or outlier map)

## Use the standard plots available for prcomp and princomp
screeplot(pca)
biplot(pca)
```

### PcaLocantore-class

*Class "PcaLocantore" Spherical Principal Components*

**Description**

The Spherical Principal Components procedure was proposed by Locantore et al., (1999) as a functional data analysis method. The idea is to perform classical PCA on the data, projected onto a unit sphere. The estimates of the eigenvectors are consistent and the procedure is extremely fast. The simulations of Maronna (2005) show that this method has very good performance.

**Objects from the Class**

Objects can be created by calls of the form `new("PcaLocantore", ...)` but the usual way of creating `PcaLocantore` objects is a call to the function `PcaLocantore` which serves as a constructor.
Slots

delta: Accuracy parameter
quan: Object of class "numeric" The quantile h used throughout the algorithm
call, center, scale, loadings, eigenvalues, scores, k, sd, od, cutoff.sd, cutoff.od, flag, n.obs: from the "Pca" class.

Extends

Class "PcaRobust", directly. Class "Pca", by class "PcaRobust", distance 2.

Methods

getQuan signature(obj = "PcaLocantore"): ...

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

PcaRobust-class, Pca-class, PcaClassic, PcaClassic-class

Examples

showClass("PcaLocantore")

Description

A fast and simple algorithm for approximating the PP-estimators for PCA: Croux and Ruiz-Gazen (2005)

Usage

PcaProj(x, ...)
## Default S3 method:
PcaProj(x, k = 0, kmax = ncol(x), scale=FALSE,
   na.action = na.fail, crit.pca.distances = 0.975, trace=FALSE, ...)
## S3 method for class 'formula'
PcaProj(formula, data = NULL, subset, na.action, ...)
Arguments

formula a formula with no response variable, referring only to numeric variables.
data an optional data frame (or similar: see `model.frame`) containing the variables in the formula `formula`.
subset an optional vector used to select rows (observations) of the data matrix `x`.
na.action a function which indicates what should happen when the data contain NAs. The default is set by the `na.action` setting of `options`, and is `na.fail` if that is unset. The default is `na.omit`.

... arguments passed to or from other methods.

x a numeric matrix (or data frame) which provides the data for the principal components analysis.
k number of principal components to compute. If `k` is missing, or \( k = 0 \), it is set to the number of columns of the data. It is preferable to investigate the scree plot in order to choose the number of components and then run again. Default is \( k = 0 \).

kmax maximal number of principal components to compute. Default is `kmax = 10`. If `k` is provided, `kmax` does not need to be specified, unless `k` is larger than 10.
scale a value indicating whether and how the variables should be scaled. If `scale = FALSE` (default) or `scale = NULL` no scaling is performed (a vector of 1s is returned in the `scale` slot). If `scale = TRUE` the data are scaled to have unit variance. Alternatively it can be a function like `sd` or `mad` or a vector of length equal the number of columns of `x`. The value is passed to the underlying function and the result returned is stored in the `scale` slot. Default is `scale = FALSE`.
crit.pca.distances criterion to use for computing the cutoff values for the orthogonal and score distances. Default is `crit.pca.distances = 0.975`.
trace whether to print intermediate results. Default is `trace = FALSE`.

Details

`PcaProj`, serving as a constructor for objects of class `PcaProj-class` is a generic function with "formula" and "default" methods. For details see `Pcaproj` and the relevant references.

Value

An S4 object of class `PcaProj-class` which is a subclass of the virtual class `PcaRobust-class`.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References

Examples

```r
# multivariate data with outliers
library(mvtnorm)
x <- rbind(rmvnorm(200, rep(0, 6), diag(c(5, rep(1, 5)))),
           rmvnorm(15, c(0, rep(20, 5)), diag(rep(1, 6))))
# Here we calculate the principal components with PcaProj
pc <- PcaProj(x, 6)
# we could draw a biplot too:
biplot(pc)

# we could use another calculation method and another objective function, and
# maybe only calculate the first three principal components:
pc <- PcaProj(x, k=3, method="qn", CalcMethod="sphere")
biplot(pc)

# now we want to compare the results with the non-robust principal components
pc <- PcaClassic(x, k=3)
# again, a biplot for comparision:
biplot(pc)
```

---

**PcaProj-class**

Class "PcaProj" - Robust PCA using PP - Croux and Ruiz-Gazen (2005) algorithm

Description


Objects from the Class

Objects can be created by calls of the form `new("PcaProj", ...)` but the usual way of creating PcaProj objects is a call to the function `PcaProj()` which serves as a constructor.

Slots

call, center, scale, loadings, eigenvalues, scores, k, sd, od, cutoff.sd, cutoff.od, flag, n.obs: from the "Pca" class.

Extends

Class "PcaRobust", directly. Class "Pca", by class "PcaRobust", distance 2.

Methods

`getQuan` signature(obj = "PcaProj"): ...
Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

PcaRobust-class, Pca-class, PcaClassic, PcaClassic-class

Examples

showClass("PcaProj")

PcaRobust-class

Class "PcaRobust" is a virtual base class for all robust PCA classes

Description

The class PcaRobust serves as a base class for deriving all other classes representing the results of the robust Principal Component Analysis methods.

Objects from the Class

A virtual Class: No objects may be created from it.

Slots

call: Object of class "language"

center: Object of class "vector" the center of the data

loadings: Object of class "matrix" the matrix of variable loadings (i.e., a matrix whose columns contain the eigenvectors)

eigenvalues: Object of class "vector" the eigenvalues

scores: Object of class "matrix" the scores - the value of the projected on the space of the principal components data (the centred (and scaled if requested) data multiplied by the loadings matrix) is returned. Hence, cov(scores) is the diagonal matrix diag(eigenvalues)

k: Object of class "numeric" number of (chosen) principal components

sd: Object of class "Uvector" Score distances within the robust PCA subspace

od: Object of class "Uvector" Orthogonal distances to the robust PCA subspace
cutoff.sd: Object of class "numeric" Cutoff value for the score distances
cutoff.od: Object of class "numeric" Cutoff values for the orthogonal distances

flag: Object of class "Uvector" The observations whose score distance is larger than cutoff.sd or whose orthogonal distance is larger than cutoff.od can be considered as outliers and receive a flag equal to zero. The regular observations receive a flag 1

n.obs: Object of class "numeric" the number of observations
Extends

Class "Pca", directly.

Methods

No methods defined with class "PcaRobust" in the signature.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

Pca-class, PcaClassic-class.

Examples

showClass("PcaRobust")

Description

Shows the Mahalanobis distances based on robust and/or classical estimates of the location and the covariance matrix in different plots. The following plots are available:
- index plot of the robust and mahalanobis distances
- distance-distance plot
- Chisquare QQ-plot of the robust and mahalanobis distances
- plot of the tolerance ellipses (robust and classic)
- Scree plot - Eigenvalues comparison plot

Usage

```r
## S4 method for signature 'CovClassic'
plot(x, which = c("all","distance","qqchi2","tolellipse","screeplot"),
     ask=(which=="all" & dev.interactive()),
     cutoff, id.n, tol=1e-7, ...)
## S4 method for signature 'CovRobust'
plot(x, which = c("all","dd","distance","qqchi2","tolellipse","screeplot"),
     classic=FALSE, ask=(which=="all" & dev.interactive()),
     cutoff, id.n, tol=1e-7, ...)
```
Arguments

- **x**: an object of class "Cov" or "CovRobust"
- **which**: Which plot to show? See Details for description of the options. Default is which="all".
- **classic**: whether to plot the classical distances too. Default is classic=FALSE.
- **ask**: logical; if 'TRUE', the user is asked before each plot, see 'par(ask=.)'. Default is ask = which="all" && dev.interactive().
- **cutoff**: The cutoff value for the distances.
- **id.n**: Number of observations to identify by a label. If not supplied, the number of observations with distance larger than cutoff is used.
- **tol**: tolerance to be used for computing the inverse see 'solve'. Default is tol = 1e-7
- **...**: other parameters to be passed through to plotting functions.

Methods

- **x = "Cov", y = "missing"** Plot mahalanobis distances for x.
- **x = "CovRobust", y = "missing"** Plot robust and classical mahalanobis distances for x.

Examples

```r
data(hbk)
hbk.x <- data.matrix(hbk[, 1:3])
cv <- CovClassic(hbk.x)
plot(cv)
rcv <- CovMest(hbk.x)
plot(rcv)
```

Description

The Archaic Greek Pottery data set contains data on fragments of Greek pottery which were classified into two groups according to their origin: Attic or Eritrean. Six chemical variables, metallic oxide constituents, were measured: Si, Al, Fe, Ca and Ti. The main data set consists of 13 Attic objects and 14 Eritrean ones. There is a separate data set with 13 observations which can be used as a test data set. It consists of 4 observations classified as "probably Attic" and the remaining 9 as "probably Eritrean".

Usage

```r
data(pottery)
pottery
pottery.test
```
Format

Two data frames with 27 and 13 observations on the following 7 variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI</td>
<td>Si content</td>
</tr>
<tr>
<td>AL</td>
<td>Al content</td>
</tr>
<tr>
<td>FE</td>
<td>Fe content</td>
</tr>
<tr>
<td>MG</td>
<td>Mg content</td>
</tr>
<tr>
<td>CA</td>
<td>Ca content</td>
</tr>
<tr>
<td>TI</td>
<td>Ti content</td>
</tr>
<tr>
<td>origin</td>
<td>Origin - factor with two levels: Attic and Eritrean</td>
</tr>
</tbody>
</table>

Details

The Archaic Greek Pottery data set was first published by Stern and Descoeudres (1977) and later reproduced in Cooper and Weeks (1983) for illustration of linear discriminant analysis. The data set was used by Pires and Branco (2010) for illustration of their projection pursuit approach to linear discriminant analysis.

Source


References


Examples

data(pottery)
x <- pottery[,c("MG", "CA")]
grp <- pottery$origin

##
## Compute robust location and covariance matrix and
## plot the tolerance ellipses
library(rrcov)
(mcd <- CovMcd(x))
col <- c(3,4)
gcol <- ifelse(grp == "Attic", col[1], col[2])
gpch <- ifelse(grp == "Attic", 16, 1)
plot(mcd, which="tolEllipsePlot", class=TRUE, col=gcol, pch=gpch)

##
## Perform classical LDA and plot the data, 0.975 tolerance ellipses and LDA separation line

```r
t # require(ellipse)
# x <- pottery[,c("Mg", "Ca")]
grp <- pottery$origin
lda <- LdaClassic(x, grp)

lda

e1 <- ellipse(lda@cov, centre=lda@center[1,])
e2 <- ellipse(lda@cov, centre=lda@center[2,])

plot(CA~Mg, data=pottery, col=gcol, pch=gpch,
    xlim=c(min(MG,e1[,1], e2[1,]), max(MG,e1[,1], e2[1,])),
    ylim=c(min(CA,e1[,2], e2[,2]), max(CA,e1[,2], e2[,2])))

ab <- lda@ldf[1,] - lda@ldf[2,]
c <- lda@ldfconst[1] - lda@ldfconst[2]
abline(a=-c/ab[2], b=-ab[1]/ab[2], col=2, lwd=2)

lines(e1, type="1", col=gcol[1])
lines(e2, type="1", col=gcol[2])
```

## Perform robust (MCD) LDA and plot data, classical and robust separation line

```r
t # require(ellipse)
plot(CA~Mg, data=pottery, col=gcol, pch=gpch)
lda <- LdaClassic(x, grp)

lda

ab <- lda@ldf[1,] - lda@ldf[2,]
c <- lda@ldfconst[1] - lda@ldfconst[2]
abline(a=-c/ab[2], b=-ab[1]/ab[2], col=2, lwd=2)
abline(a=-c/ab[2], b=-ab[1]/ab[2], col=4, lwd=2)

rlda <- Lda(x, grp, method="mcd")
rlda

ab <- rlda@ldf[1,] - rlda@ldf[2,]
c <- rlda@ldfconst[1] - rlda@ldfconst[2]
abline(a=-c/ab[2], b=-ab[1]/ab[2], col=2, lwd=2)
```

---

**PredictLda-class**

Class "PredictLda" - prediction of "Lda" objects

### Description

The prediction of a "Lda" object
Objects from the Class

Objects can be created by calls of the form `new("PredictQda", ...)` but most often by invoking 'predict' on a "Lda" object. They contain values meant for printing by 'show'.

Slots

classification: a factor variable containing the classification of each object
posterior: a matrix containing the posterior probabilities
x: matrix with the discriminant scores
c: re-classification table of the training sample

Methods

`show` signature(object = "PredictQda"): Prints the results

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

`Lda-class`

Examples

`showClass("PredictQda")`
Qda-class

Slots

classification: a factor variable containing the classification of each object
posterior: a matrix containing the posterior probabilities
x: matrix with the discriminant scores
ct: re-classification table of the training sample

Methods

show signature(object = "PredictQda"): prints the results

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

Qda-class

Examples

showClass("PredictQda")

Description

The class Qda serves as a base class for deriving all other classes representing the results of classical and robust Quadratic Discriminant Analysis methods

Objects from the Class

A virtual Class: No objects may be created from it.
Slots

call: the (matched) function call.
prior: prior probabilities used, default to group proportions
counts: number of observations in each class
center: the group means
cov: the group covariance matrices
covinv: the inverse of the group covariance matrices
covdet: the determinants of the group covariance matrices
method: a character string giving the estimation method used
X: the training data set (same as the input parameter x of the constructor function)
grp: grouping variable: a factor specifying the class for each observation.
control: object of class "CovControl" specifying which estimate and with what estimation options to use for the group means and covariances (or NULL for classical discriminant analysis)

Methods

predict signature(object = "Qda"): calculates prediction using the results in object. An optional data frame or matrix in which to look for variables with which to predict. If omitted, the scores are used. If the original fit used a formula or a data frame or a matrix with column names, newdata must contain columns with the same names. Otherwise it must contain the same number of columns, to be used in the same order.

show signature(object = "Qda"): prints the results

summary signature(object = "Qda"): prints summary information

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

QdaClassic, QdaClassic-class, QdaRobust-class

Examples

showClass("Qda")
QdaClassic

Quadratic Discriminant Analysis

Description
Perform quadratic discriminant analysis and returns the results as an object of class QdaClassic (aka constructor).

Usage
QdaClassic(x, ...)

## Default S3 method:
QdaClassic(x, grouping, prior = proportions, tol = 1.0e-4, ...)

Arguments
- `x` a matrix or data frame containing the explanatory variables (training set).
- `grouping` grouping variable: a factor specifying the class for each observation.
- `prior` prior probabilities, default to the class proportions for the training set.
- `tol` tolerance
- `...` arguments passed to or from other methods.

Value
Returns an S4 object of class QdaClassic

Author(s)
Valentin Todorov <valentin.todorov@chello.at>

References

See Also
Qda-class, QdaClassic-class,
Class "QdaClassic" - Quadratic Discriminant Analysis

Description

Contains the results of classical Quadratic Discriminant Analysis.

Objects from the Class

Objects can be created by calls of the form `new("QdaClassic", ...)` but the usual way of creating QdaClassic objects is a call to the function `QdaClassic` which serves as a constructor.

Slots

call: The (matched) function call.
prior: Prior probabilities used, default to group proportions
counts: number of observations in each class
center: the group means
cov: the group covariance matrices
covinv: the inverse of the group covariance matrices
covdet: the determinants of the group covariance matrices
method: a character string giving the estimation method used
X: the training data set (same as the input parameter x of the constructor function)
grp: grouping variable: a factor specifying the class for each observation.
control: Object of class "CovControl" inherited from class Qda specifying which estimate and with what estimation options to use for the group means and covariances. It is always NULL for classical discriminant analysis.

Extends

Class "Qda", directly.

Methods

No methods defined with class "QdaClassic" in the signature.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References

See Also

QdaRobust-class, Qda-class, QdaClassic

Examples

showClass("QdaClassic")

---

**QdaCov**

*Robust Quadratic Discriminant Analysis*

**Description**

Performs robust quadratic discriminant analysis and returns the results as an object of class QdaCov (aka constructor).

**Usage**

QdaCov(x, ...)

## Default S3 method:
QdaCov(x, grouping, prior = proportions, tol = 1.0e-4, 
        method = CovControlMcd(), ...)

**Arguments**

- **x**  
  a matrix or data frame containing the explanatory variables (training set).

- **grouping**  
  grouping variable: a factor specifying the class for each observation.

- **prior**  
  prior probabilities, default to the class proportions for the training set.

- **tol**  
  tolerance

- **method**  
  method

- **...**  
  arguments passed to or from other methods

**Details**

details

**Value**

Returns an S4 object of class QdaCov

**Warning**

Still an experimental version!

**Author(s)**

Valentin Todorov <valentin.todorov@chello.at>
QdaCov-class

References

See Also
CovMcd

Examples

```r
## Example anorexia
library(MASS)
data(anorexia)

## start with the classical estimates
qda <- QdaClassic(Treat~, data=anorexia)
predict(qda)@classification

## try now the robust LDA with the default method (MCD with pooled whitin cov matrix)
rqda <- QdaCov(Treat~, data= anorexia)
predict(rqda)@classification

## try the other methods
QdaCov(Treat~, data= anorexia, method="sde")
QdaCov(Treat~, data= anorexia, method="M")
QdaCov(Treat~, data= anorexia, method=CovControlOgk())
```

Description

Robust quadratic discriminant analysis is performed by replacing the classical group means and withing group covariance matrices by their robust equivalents.

Objects from the Class

Objects can be created by calls of the form new("QdaCov", ...) but the usual way of creating QdaCov objects is a call to the function QdaCov which serves as a constructor.

Slots

call: The (matched) function call.
prior: Prior probabilities used, default to group proportions
counts: number of observations in each class
center: the group means
cov: the group covariance matrices
covinv: the inverse of the group covariance matrices
covdet: the determinants of the group covariance matrices
method: a character string giving the estimation method used
X: the training data set (same as the input parameter x of the constructor function)
grp: grouping variable: a factor specifying the class for each observation.
control: Object of class "CovControl" specifying which estimate to use for the group means and covariances

Extends
Class "QdaRobust", directly. Class "Qda", by class "QdaRobust", distance 2.

Methods
No methods defined with class "QdaCov" in the signature.

Author(s)
Valentin Todorov <valentin.todorov@chello.at>

References

See Also
QdaRobust-class, Qda-class, QdaClassic, QdaClassic-class

Examples
showClass("QdaCov")

---

**QdaRobust-class**

*Class "QdaRobust" is a virtual base class for all robust QDA classes*

**Description**

The class QdaRobust serves as a base class for deriving all other classes representing the results of robust Quadratic Discriminant Analysis methods

**Objects from the Class**

A virtual Class: No objects may be created from it.
**Slots**

- **call**: The (matched) function call.
- **prior**: Prior probabilities used, default to group proportions
- **counts**: Number of observations in each class
- **center**: The group means
- **cov**: The group covariance matrices
- **covinv**: The inverse of the group covariance matrices
- **covdet**: The determinants of the group covariance matrices
- **method**: A character string giving the estimation method used
- **x**: The training data set (same as the input parameter `x` of the constructor function)
- **grp**: Grouping variable: A factor specifying the class for each observation.
- **control**: Object of class "CovControl" specifying which estimate to use for the group means and covariances

**Extends**

Class "Qda", directly.

**Methods**

No methods defined with class "QdaRobust" in the signature.

**Author(s)**

Valentin Todorov <valentin.todorov@chello.at>

**References**


**See Also**

- `Qda-class`, `QdaClassic-class`

**Examples**

```r
showClass("QdaRobust")
```
Description

Each concrete control class, like CovControlMcd, CovControlOgk, etc., should implement an estimate method which will call the corresponding (constructor)-function and will return the obtained S4 class, derived from CovRobust.

Usage

```r
## S4 method for signature 'CovControlMcd'
restimate(obj, x, ...)
```

Arguments

- `obj`: an object of class "CovControlEstimate"
- `x`: Data frame or matrix containing the data.
- `...`: other parameters to be passed through to the estimation function.

Methods

- `obj = "CovControlMcd"` Compute the MCD estimates of multivariate location and scatter by callingCovMcd
- `obj = "CovControlMest"` Compute the constrained M-estimates of multivariate location and scatter by callingCovMest
- `obj = "CovControlOgk"` Compute the Ortogonalized Gnanadesikan-Kettenring (OGK) estimates of multivariate location and scatter by callingCovOgk

Rice taste data

The rice taste data consists of five inputs and a single output whose values are associated with subjective evaluations as follows: x1: flavor, x2: appearance, x3: taste, x4: stickiness, x5: toughness, y: overall evaluation. Sensory test data have been obtained by such subjective evaluations for 105 kinds of rice (e.g., Sasanishiki, Akita-Komachi, etc.). The data set was used by Nozaki et al. (1997) to demonstrate the high performance of a proposed for automatically generating fuzzy if-then rules from numerical data.

Usage

```r
data(rice)
```
salmon

Format
A data frame with 105 observations on the following 6 variables:

- Favor compactness
- Appearance circularity
- Taste distance circularity
- Stickiness radius ratio
- Toughness principal axis aspect ratio
- Overall_evaluation maximum length aspect ratio

Source

Salmon data

Description
The salmon data contains two measurements of the growth rings on the scale of Alaskan and Canadian salmon as well as the gender of the fishes. There are 50 Alaskan-born and 50 Canadian-born salmon, and this information is coded in the variable *Origin*.

Usage
data(salmon)

Format
A data frame with 100 observations on the following 4 variables.

- Gender female=1 and male=2
- Freshwater diameter of rings for the first-year freshwater growth (hundrets of an inch)
- Marine diameter of rings for the first-year marine growth (hundrets of an inch)
- Origin Origin of the fish: a factor with levels Alaskan Canadian

Source

Examples
data(salmon)
scorePlot-methods

Score plot for Principal Components (objects of class 'Pca')

Description

Produces a score plot from an object (derived from) \texttt{Pca-class}.

Usage

\begin{verbatim}
## S4 method for signature 'Pca'
scorePlot(x, i=1, j=2, ...)
\end{verbatim}

Arguments

\begin{itemize}
\item \texttt{x} an object of class (derived from) "Pca".
\item \texttt{i} First score coordinate, defaults to i=1.
\item \texttt{j} Second score coordinate, defaults to j=2.
\item \texttt{...} optional arguments to be passed to the internal graphical functions.
\end{itemize}

Side Effects

a plot is produced on the current graphics device.

Methods

\texttt{scorePlot signature(x = Pca)}: Plot a scatter plot of \texttt{i}th against \texttt{j}th score of the \texttt{Pca} object with superimposed tollerance (0.975) ellipse. See also \texttt{biplot, screeplot}.

See Also

\texttt{Pca-class, PcaClassic, PcaRobust-class}.

Examples

require(graphics)

\begin{verbatim}
## PCA of the Hawkins Bradu Kass's Artificial Data
## using all 4 variables
data(hbk)
pca <- PcaHubert(hbk)
pca

scorePlot(pca)
\end{verbatim}
SummaryCov-class

Class "SummaryCov" - summary of "Cov" objects

Description

The "Cov" object plus some additional summary information

Objects from the Class

Objects can be created by calls of the form new("SummaryCov", ...), but most often by invoking 'summary' on a "Cov" object. They contain values meant for printing by 'show'.

Slots

covobj: Object of class "Cov"
evals: eigenvalues of the covariance or correlation matrix

Methods

getCenter signature(obj = "SummaryCov"): location vector
getCov signature(obj = "SummaryCov"): covariance matrix
getDistance signature(obj = "SummaryCov"): vector of distances
getEvals signature(obj = "SummaryCov"): vector of eigenvalues
isClassic signature(obj = "SummaryCov"): is the estimate a classic one
show signature(object = "SummaryCov"): display the object

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

Cov-class

Examples

showClass("SummaryCov")
SummaryCovRobust-class

Class "SummaryCovRobust" - summary of "CovRobust" objects

Description

Summary information for CovRobust objects meant for printing by 'show'.

Objects from the Class

Objects can be created by calls of the form new("SummaryCovRobust", ...), but most often by invoking 'summary' on an "Cov" object. They contain values meant for printing by 'show'.

Slots

covobj: Object of class "Cov"
evals: Eigenvalues of the covariance or correlation matrix

Extends

Class "SummaryCov", directly.

Methods

show signature(object = "SummaryCovRobust"): ...
Class "SummaryLda" - summary of "Lda" objects

Description

Contains summary information about an Lda object - Linear Discriminant Analysis object

Objects from the Class

Objects can be created by calls of the form `new("SummaryLda", ...), but most often by invoking 'summary' on an "Lda" object. They contain values meant for printing by 'show'.

Slots

`ldaobj`: Object of class "Lda"

Methods

`show` signature(object = "SummaryLda"): display the object

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

*Lda-class*

Examples

`showClass("SummaryLda")`
SummaryPca-class

Class "SummaryPca" - summary of "Pca" objects

Description

The "Pca" object plus some additional summary information

Objects from the Class

Objects can be created by calls of the form new("SummaryPca", ...), but most often by invoking 'summary' on a "Pca" object. They contain values meant for printing by 'show'.

Slots

pcaobj: Object of class "Pca"

importance: matrix with additional information: importance of components

Methods

show signature(object = "SummaryPca"): display the object

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

Pca-class

Examples

showClass("SummaryPca")
SummaryQda-class

Class "SummaryQda" - summary of "Qda" objects

Description

Summary information about a Qda - Quadratic Discriminant Analysis object

Objects from the Class

Objects can be created by calls of the form new("SummaryQda", ...), but most often by invoking 'summary' on an "Qda" object. They contain values meant for printing by 'show'.

Slots

qdaobj: Object of class "Qda"

Methods

show signature(object = "SummaryQda"): display the object

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

Qda-class

Examples

showClass("SummaryQda")
Robust Hotelling T2 test

Description
Performs one and two sample Hotelling T2 tests as well as robust one-sample Hotelling T2 test

Usage
T2.test(x, ...)

## Default S3 method:
T2.test(x, y = NULL, mu = 0, conf.level = 0.95, method=c("c", "mcd"), ...)

## S3 method for class 'formula'
T2.test(formula, data, subset, na.action, ...)

Arguments
- x: a (non-empty) numeric data frame or matrix.
- y: an optional (non-empty) numeric data frame or matrix.
- mu: an optional (non-empty) numeric vector of data values (or a single number which will be repeated p times) indicating the true value of the mean (or difference in means if you are performing a two sample test).
- conf.level: confidence level of the interval
- method: the method to be used - 'c' for sample mean and covariance matrix and 'mcd' for minimum covariance determinant estimator. A two-sample MCD based T2-test is not yet implemented.
- formula: a formula of the form lhs ~ rhs where lhs is a numeric data frame or matrix giving the observations and rhs a factor with two levels giving the corresponding groups.
- data: an optional matrix or data frame (or similar: see model.frame) containing the variables in the formula formula. By default the variables are taken from environment(formula).
- subset: an optional vector specifying a subset of observations to be used (currently not used)
- na.action: a function which indicates what should happen when the data contain NAs. Defaults togetOption("na.action") (currently only "na.rm" used)
- ...: further arguments to be passed to or from methods.

Details
The formula interface is only applicable for the two-sample tests.
Value

A list with class "htest" containing the following components:

- statistic: the value of the T2-statistic.
- parameter: the degrees of freedom for the T2-statistic.
- p.value: the p-value for the test.
- conf.int: a confidence interval for the mean vector appropriate to the specified alternative hypothesis.
- estimate: the estimated mean vector or vectors depending on whether it was a one-sample test or a two-sample test.
- null.value: the specified hypothesized value of the mean or mean difference depending on whether it was a one-sample test or a two-sample test.
- alternative: a character string describing the alternative hypothesis.
- method: a character string indicating what type of T2-test was performed.
- data.name: a character string giving the name(s) of the data.

Author(s)

Valentin Todorov <valentin.todorov@chello.at>

References


See Also

- CovMcd

Examples

```r
## One-sample classical test
data(delivery)
delivery.x <- delivery[,1:2]
T2.test(delivery.x)

## One-sample robust test
data(delivery)
delivery.x <- delivery[,1:2]
T2.test(delivery.x, method="mcd")

## Two-sample classical test
data(hemophilia)
grp <- as.factor(hemophilia[,3])
x <- hemophilia[which(grp==levels(grp)[1]),1:2]
y <- hemophilia[which(grp==levels(grp)[2]),1:2]
T2.test(x,y)
```
## Description

This data set consists of seven socioeconomic variables observed for 73 countries.

## Usage

```r
data(un86)
```

## Format

A data frame with 73 observations on the following 7 variables.

- **POP** Total population in millions
- **MOR** Number of infant deaths per thousand births
- **CAR** Number of motorized vehicles per hundred inhabitants
- **DR** Number of medical doctors per thousand inhabitants
- **GNP** Gross national product per inhabitant in thousands of US dollars
- **DEN** Density in inhabitants per square kilometer
- **TB** Trade balance, defined as total exports/(total exports + total imports)

## Details

The data set is from World Statistics in Brief, Number 10, a 1986 UN publication. It was used in Daigle et al. (1992) to illustrate a robust biplot method.

## Source

- World Statistics in Brief, Number 10, a 1986 United Nations publication

## Examples

```r
data(un86)
pairs(un86)
```
**Description**

The data are from a national sample of 6000 households with a male head earning less than USD 15,000 annually in 1966. The data were classified into 39 demographic groups for analysis. The study was undertaken in the context of proposals for a guaranteed annual wage (negative income tax). At issue was the response of labor supply (average hours) to increasing hourly wages. The study was undertaken to estimate this response from available data.

**Usage**

```r
data(wages)
```

**Format**

A data frame with 39 observations on the following 10 variables:

- `hrs` Average hours worked during the year
- `rate` Average hourly wage (USD)
- `ersp` Average yearly earnings of spouse (USD)
- `erno` Average yearly earnings of other family members (USD)
- `nein` Average yearly non-earned income
- `asset` Average family asset holdings (Bank account, etc.) (USD)
- `age` Average age of respondent
- `dep` Average number of dependents
- `race` Percent of white respondents
- `school` Average highest grade of school completed

**Source**

DASL library

'http://lib.stat.cmu.edu/DASL/Datafiles/wagesdat.html'

**References**

Examples

data(wages)
names(wages)
x <- as.matrix(wages)
ok <- is.finite(x %*% rep(1, ncol(x)))
wages <- wages[ok, , drop = FALSE]
wages.lm <- lm(HRS~AGE, data=wages)
plot(HRS ~ AGE, data = wages)
abline(wages.lm)
class(wages.lm)
names(wages.lm)
summary(wages.lm)

wages.mm <- lmrob(HRS~AGE, data=wages)
plot(HRS ~ AGE, data = wages)
abline(wages.mm)
class(wages.mm)
names(wages.mm)
summary(wages.mm)

Wilks.test

Classical and Robust One-way MANOVA: Wilks Lambda

Description

Classical and Robust One-way MANOVA: Wilks Lambda

Usage

## S3 method for class 'formula'
Wilks.test(formula, data, ..., subset, na.action)

## Default S3 method:
Wilks.test(x, grouping, method=c("c", "mcd", "rank"),
  approximation=c("Bartlett", "Rao", "empirical"),
  xd=NULL, xq=NULL, xfn = NULL, xwl=NULL, nrep=3000, trace=FALSE, ...)

## S3 method for class 'data.frame'
Wilks.test(x, ...)

## S3 method for class 'matrix'
Wilks.test(x, grouping, ..., subset, na.action)

Arguments

formula A formula of the form groups ~ x1 + x2 + ... That is, the response is the
  grouping factor and the right hand side specifies the (non-factor) variables.
Wilks.test

data Data frame from which variables specified in formula are to be taken.
x (required if no formula is given as the principal argument) a matrix or data frame or Matrix containing the explanatory variables.
grouping grouping variable - a factor specifying the class for each observation (required if no formula argument is given.)
subset An index vector specifying the cases to be used.
na.action A function to specify the action to be taken if NAs are found. The default action is for the procedure to fail. An alternative is na.omit, which leads to rejection of cases with missing values on any required variable.
method "c" for standard estimators of the mean and variance, "mcd" for MCD estimators of mean and variances and "rank" for rank based wilks’ lambda as proposed by Nath and Pavur (1985).
approximation "Bartlett" for Bartlett approximation (default), "Rao" for rao approximation (only for method="c") and "empirical" for simulated empirical distribution.
xd multiplication factor for the approximate distribution of the robust Lambda statistic. If xd=NULL the factor will be computed by simulation and will be returned in the value (see Details)
xq the degrees of freedom for the approximate $\chi^2$ distribution of the robust Lambda statistic. If xq=NULL the degrees of freedom will be computed by simulation and will be returned in the value (see Details)
xfn the empirical distribution function. If xfn=NULL the empirical function will be estimated by simulation and will be returned in the value (see Details)
xwl the simulated values of the robust statistic. If xwl=NULL the simulation will be performed and the calculated result will be returned in the value (see Details)
nrep number of trials for the simulations for computing the multiplication factor xd and the degrees of freedom xq. Default is nrep=3000.
trace whether to print intermediate results. Default is trace = FALSE
... arguments passed to or from other methods.

Details

The classical Wilks’ Lambda statistic for testing the equality of the group means of two or more groups is modified into a robust one through substituting the classical estimates by the highly robust and efficient reweighted MCD estimates, which can be computed efficiently by the FAST-MCD algorithm - see CovMcd. An approximation for the finite sample distribution of the Lambda statistic is obtained, based on matching the mean and variance of a multiple of an $\chi^2$ distribution which are computed by simuataion.

Value

A list with class "htest" containing the following components:

statistic the value of the Wilks’ Lambda statistic.
parameter The corresponding approximation of the Wilks’ lambda statistic and the degrees of freedom.
p.value the p-value for the test.
estimate the estimated mean vectors.
method a character string indicating what type of test was performed.
data.name a character string giving the name of the data.
xd multiplication factor for the approximate distribution of the robust Lambda statistic.
xq the degrees of freedom for the approximate $\chi^2$ distribution of the robust Lambda statistic.

Note
This function may be called giving either a formula and optional data frame, or a matrix and grouping factor as the first two arguments. All other arguments are optional.

Author(s)
Valentin Todorov <valentin.todorov@chello.at>

References

See Also
CovMcd, T2.test

Examples
library(MASS)
data(anorexia)
grp <- as.factor(anorexia[,1])
x <- as.matrix(anorexia[,2:3])
## Using the default interface, classical test
Wilks.test(x, grouping=grp, method="c")

## Using the default interface, rank based test
Wilks.test(x, grouping=grp, method="rank")

## For this data set: p=2, n=n1+n2+n3=29+26+17
## were computed the following multiplication factor xd and degrees of freedom xq
## for the MCD estimates with alpha=0.5
xd <- -0.02162666
xq <- 3.63971
Wilks.test(x, grouping=grp, method="mcd", xd=xd, xq=xq)
```r
## Now the same with the formula interface
Wilks.test(Treat~Prewt+Postwt, data=anorexia, method="mcd", xd=xd, xq=xq)

## Iris data with formula interface
data(iris)
Wilks.test(Species~., data=iris, method="c")

## and with default interface
Wilks.test(iris[,1:4],grouping=iris[,5], method="c")

# hemophilia data - classical, rank and MCD test
data(hemophilia)
hemophilia$gr <- as.factor(hemophilia$gr)

Wilks.test(gr~., data=hemophilia, method="c")
Wilks.test(gr~., data=hemophilia, method="rank")
## already simulated parameters for MCD with alpha=0.5
xd <- -0.01805436
xq <- 1.950301
Wilks.test(gr~., data=hemophilia, xd=xd, xq=xq, method="mcd")
```
Index

*Topic **classes**
  Cov-class, 11
  CovClassic, 13
  CovClassic-class, 14
  CovControl-class, 15
  CovControlMcd, 16
  CovControlMcd-class, 17
  CovControlMest, 18
  CovControlMest-class, 19
  CovControlMMest, 20
  CovControlMMest-class, 21
  CovControlMve, 23
  CovControlMve-class, 24
  CovControlOgk, 25
  CovControlOgk-class, 26
  CovControlSde, 27
  CovControlSde-class, 29
  CovControlSest, 30
  CovControlSest-class, 31
  CovMcd-class, 34
  CovMest-class, 40
  CovMMest-class, 43
  CovMve-class, 46
  CovOgk-class, 49
  CovRobust-class, 52
  CovSde-class, 55
  CovSest-class, 59
  Lda-class, 65
  PredictLda-class, 110
  PredictQda-class, 111
  Qda-class, 112
  QdaClassic-class, 115
  QdaCov-class, 117
  QdaRobust-class, 118
  restimate-methods, 120
  SummaryCov-class, 123
  SummaryCovRobust-class, 124
  SummaryLda-class, 125
  SummaryPca-class, 126

*Topic **datasets**
  Appalachia, 3
  bus, 6
  bushmiss, 8
  Cascades, 10
  fish, 60
  hemophilia, 63
  lmom32, 77
  lmom33, 78
  maryo, 80
  OsloTranssect, 81
  pottery, 108
  rice, 120
  salmon, 121
  un68, 130
  wages, 131

*Topic **hplot**
  biplot-methods, 5
  scorePlot-methods, 122

*Topic **htest**
  T2.test, 128

*Topic **methods**
  getCenter-methods, 61
  getLoadings-methods, 62
  plot-methods, 107

*Topic **multivariate**
  biplot-methods, 5
  Cov-class, 11
  CovClassic, 13
  CovClassic-class, 14
  CovControl-class, 15
  CovControlMcd, 16
  CovControlMcd-class, 17
  CovControlMest, 18
  CovControlMest-class, 19
  CovControlMMest, 20
  CovControlMMest-class, 21
  CovControlMve, 23
INDEX

CovControlMve-class, 24
CovControlOgk, 25
CovControlOgk-class, 26
CovControlSde, 27
CovControlSde-class, 29
CovControlSest, 30
CovControlSest-class, 31
CovMcd, 32
CovMcd-class, 34
CovMest, 36
covMest, 38
CovMest-class, 40
CovMest, 41
CovMMest-class, 43
CovMve, 44
CovMve-class, 46
CovOgk, 47
CovOgk-class, 49
CovRobust, 50
CovRobust-class, 52
CovSde, 53
CovSde-class, 55
CovSest, 56
CovSest-class, 59
getCenter-methods, 61
getLoadings-methods, 62
isSingular-methods, 64
Lda-class, 65
LdaClassic, 66
LdaClassic-class, 67
LdaPP, 68
LdaPP-class, 71
LdaRobust-class, 72
Linda, 74
Linda-class, 76
Pca-class, 83
pca.distances, 85
pca.scoreplot, 86
PcaClassic, 87
PcaClassic-class, 88
PcaCov, 90
PcaCov-class, 92
PcaGrid, 93
PcaGrid-class, 95
PcaHubert, 96
PcaHubert-class, 99
PcaLocantore, 100
PcaLocantore-class, 102

PcaProj, 103
PcaProj-class, 105
PcaRobust-class, 106
PredictLda-class, 110
PredictQda-class, 111
Qda-class, 112
QdaClassic, 114
QdaClassic-class, 115
QdaCov, 116
QdaCov-class, 117
QdaRobust-class, 118
restimate-methods, 120
scorePlot-methods, 122
SummaryCovRobust-class, 124
SummaryLda-class, 125
SummaryPca-class, 126
SummaryQda-class, 127
T2.test, 128
Wilks.test, 132

*Topic robust
Cov-class, 11
CovClassic, 13
CovClassic-class, 14
CovControl-class, 15
CovControlMcd, 16
CovControlMcd-class, 17
CovControlMest, 18
CovControlMest-class, 19
CovControlMMest, 20
CovControlMMest-class, 21
CovControlMve, 23
CovControlMve-class, 24
CovControlOgk, 25
CovControlOgk-class, 26
CovControlSde, 27
CovControlSde-class, 29
CovControlSest, 30
CovControlSest-class, 31
CovMcd, 32
CovMcd-class, 34
CovMest, 36
covMest, 38
CovMest-class, 40
CovMest, 41
CovMMest-class, 43
CovMve, 44
CovMve-class, 46
CovOgk, 47
CovOgk-class, 49
CovRobust, 50
CovRobust-class, 52
CovSde, 53
CovSde-class, 55
CovSest, 56
CovSest-class, 59
getCenter-methods, 61
getLoadings-methods, 62
isSingular-methods, 64
Lda-class, 65
LdaClassic, 66
LdaClassic-class, 67
LdaPP, 68
LdaPP-class, 71
LdaRobust-class, 72
Linda, 74
Linda-class, 76
Pca-class, 83
pca.distances, 85
pca.scoreplot, 86
PcaClassic, 87
PcaClassic-class, 88
PcaCov, 90
PcaCov-class, 92
PcaGrid, 93
PcaGrid-class, 95
PcaHubert, 96
PcaHubert-class, 99
PcaLocantore, 100
PcaLocantore-class, 102

PcaProj, 103
PcaProj-class, 105
PcaRobust-class, 106
PredictLda-class, 110
PredictQda-class, 111
Qda-class, 112
QdaClassic, 114
QdaClassic-class, 115
QdaCov, 116
QdaCov-class, 117
QdaRobust-class, 118
restimate-methods, 120
scorePlot-methods, 122
SummaryCovRobust-class, 124
SummaryLda-class, 125
SummaryPca-class, 126
SummaryQda-class, 127
T2.test, 128
Wilks.test, 132

*Topic robust
Cov-class, 11
CovClassic, 13
CovClassic-class, 14
CovControl-class, 15
CovControlMcd, 16
CovControlMcd-class, 17
CovControlMest, 18
CovControlMest-class, 19
CovControlMMest, 20
CovControlMMest-class, 21
CovControlMve, 23
CovControlMve-class, 24
CovControlOgk, 25
CovControlOgk-class, 26
CovControlSde, 27
CovControlSde-class, 29
CovControlSest, 30
CovControlSest-class, 31
CovMcd, 32
CovMcd-class, 34
CovMest, 36
covMest, 38
CovMest-class, 40
CovMest, 41
CovMMest-class, 43
CovMve, 44
CovMve-class, 46
CovOgk, 47
| CovOgk-class, 49         | biplot, 122            |
| CovRobust, 50           | biplot (biplot-methods), 5 |
| CovRobust-class, 52     | biplot, ANY-method (biplot-methods), 5 |
| CovSde, 53              | biplot, Pca-method (biplot-methods), 5 |
| CovSde-class, 55        | biplot-methods, 5        |
| CovSest, 56             | biplot.princomp, 5       |
| CovSest-class, 59       | bus, 6                  |
| getCenter-methods, 61   | bushfire, 8             |
| getLoadings-methods, 62 | bushmiss, 8             |
| Lda-class, 65           | Cascades, 10            |
| LdaClassic, 66          | Cov, 35, 40, 43, 46, 50, 52, 55, 59 |
| LdaClassic-class, 67    | Cov (CovClassic), 13    |
| LdaPP, 68               | Cov-class, 11           |
| LdaPP-class, 71         | cov.mcd, 34             |
| LdaRobust-class, 72     | cov.mve, 45             |
| Linda, 74               | CovClassic, 13, 64, 90  |
| Linda-class, 76         | CovClassic-class, 14    |
| Pca-class, 83           | CovControl, 17, 19, 20, 22, 24, 27, 29, 31 |
| pca.distances, 85       | CovControl-class, 15    |
| pca.scoreplot, 86       | CovControlMcd, 16       |
| PcaClassic, 87          | CovControlMcd-class, 17 |
| PcaClassic-class, 88    | CovControlMest, 18      |
| PcaCov, 90              | CovControlMest-class, 19|
| PcaCov-class, 92        | CovControlMMest, 20     |
| PcaGrid, 93             | CovControlMMest-class, 21|
| PcaGrid-class, 95       | CovControlMve, 23       |
| PcaHubert, 96           | CovControlMve-class, 24 |
| PcaHubert-class, 99     | CovControlOgk, 25, 48   |
| PcaLocantore, 100       | CovControlOgk-class, 26 |
| PcaLocantore-class, 102 | CovControlSde, 27       |
| PcaProj, 103            | CovControlSde-class, 29 |
| PcaProj-class, 105      | CovControlSest, 30      |
| PcaRobust-class, 106    | CovControlSest-class, 31|
| PredictLda-class, 110   | covOGK, 25              |
| PredictQda-class, 111   | CovMcd, 32, 35, 48, 54, 75, 90, 97, 117, 129, 133, 134 |
| Qda-class, 112          | covMcd, 33, 37, 40      |
| QdaClassic, 114         | CovMcd-class, 34        |
| QdaClassic-class, 115   | CovMest, 36, 41, 45, 48 |
| QdaCov, 116             | covMest, 38             |
| QdaCov-class, 117       | CovMest-class, 40       |
| QdaRobust-class, 118    | CovMEMest, 41, 43       |
| restimate-methods, 120  | CovMEMest-class, 43     |
| SummaryCovRobust-class, 124 | CovMve, 36–39, 44, 47 |
| SummaryLda-class, 125   | CovMve-class, 46        |
| SummaryPca-class, 126   | CovOGk, 47, 54          |
| SummaryQda-class, 127   | CovOGk-class, 49        |
| Wilks.test, 132         | CovRobust, 35, 40, 43, 46, 50, 54, 55, 59 |
isClassic, Cov-method (Cov-class), 11
isClassic, CovRobust-method (CovRobust-class), 52
isClassic, method (Cov-class), 11
isClassic, SummaryCov-method (SummaryCov-class), 123
isClassic, SummaryCovRobust-method (SummaryCovRobust-class), 124
isClassic-methods (getCenter-methods), 61
isSingular (isSingular-methods), 64
isSingular, ANY-method (isSingular-methods), 64
isSingular, Cov-method (isSingular-methods), 64
isSingular-methods, 64

Lda, 67, 72, 73, 76
Lda-class, 65
LdaClassic, 66, 66, 68, 70, 72, 77
LdaClassic-class, 67
LdaPP, 68, 71
LdaPP-class, 71
LdaRobust, 72, 76
LdaRobust-class, 72
Linda, 70, 72, 74
Linda-class, 76
list, 39
lmom32, 77
lmom33, 78

mahalanobis, 15, 28, 30, 56
maryo, 80
match.call, 39
model.frame, 68, 87, 90, 93, 96, 100, 104, 128
model.frame.Wilks.test (Wilks.test), 132
na.fail, 69, 87, 90, 93, 96, 100, 104
na.omit, 69, 87, 90, 93, 96, 100, 104

optim, 69
options, 69, 87, 90, 93, 96, 100, 104
OsloTransect, 81

Pca, 89, 92, 95, 99, 103, 105, 107
Pca-class, 83
pca.distances, 85
pca.scoreplot, 86
PcaClassic, 5, 85, 86, 87, 89, 93, 95, 100, 103, 106, 122
PcaClassic-class, 88
PcaCov, 90
PcaCov-class, 92
PCAgrid, 94
PcaGrid, 93
PcaGrid-class, 95
PcaHubert, 96
PcaHubert-class, 99
PcaLocantore, 100
PcaLocantore-class, 102
PCAproj, 104
PcaProj, 103
PcaProj-class, 105
PcaRobust, 92, 95, 99, 103, 105
PcaRobust-class, 106
plot (Cov-class), 11
plot, Cov, missing-method (Cov-class), 11
plot, CovClassic, missing-method (plot-methods), 107
plot, CovClassic-method (plot-methods), 107
plot, CovRobust, missing-method (plot-methods), 107
plot, CovRobust-method (plot-methods), 107
plot, Pca, missing-method (Pca-class), 83
plot-methods, 107
plot.prcomp, 84
plot.princomp, 84
pottery, 108
predict (Pca-class), 83
predict, Lda-method (Lda-class), 65
predict, LdaPP-method (LdaPP-class), 71
predict, Pca-method (Pca-class), 83
predict, Qda-method (Qda-class), 112
predict.prcomp, 84
predict.princomp, 84
PredictLda-class, 110
PredictQda-class, 111
Qda, 115, 118, 119
Qda-class, 112
QdaClassic, 113, 114, 116, 118
QdaClassic-class, 115
QdaCov, 116
QdaCov-class, 117
QdaRobust, 118
QdaRobust-class, 118
Qn, 57
INDEX

restimate (restimate-methods), 120
restimate, CovControlMcd-method (CovControlMcd-class), 17
restimate, CovControlMest-method (restimate-methods), 120
restimate, CovControlMve-method (CovControlMve-class), 24
restimate, CovControlOgk-method (CovControlOgk-class), 26
restimate, CovControlSde-method (CovControlSde-class), 29
restimate, CovControlOsest-method (CovControlOsest-class), 31
restimate-methods, 120
rice, 120
rrcov.control, 16, 33

salmon, 121
scaleTau2, 25, 57
scorePlot (scorePlot-methods), 122
scorePlot, ANY-method (scorePlot-methods), 122
scorePlot, Pca-method (scorePlot-methods), 122
scorePlot-methods, 122
screeplot, 122
screeplot (Pca-class), 83
screeplot, Pca-method (Pca-class), 83
show, Cov-method (Cov-class), 11
show, CovRobust-method (CovRobust-class), 52
show, Lda-method (Lda-class), 65
show, Pca-method (Pca-class), 83
show, PredictLda-method (PredictLda-class), 110
show, PredictQda-method (PredictQda-class), 111
show, Qda-method (Qda-class), 112
show, SummaryCov-method (SummaryCov-class), 123
show, SummaryCovRobust-method (SummaryCovRobust-class), 124
show, SummaryLda-method (SummaryLda-class), 125
show, SummaryPca-method (SummaryPca-class), 126

show, SummaryQda-method (SummaryQda-class), 127
solve, 15, 28, 30, 56
summary, Cov-method (Cov-class), 11
summary, CovRobust-method (CovRobust-class), 52
summary, Lda-method (Lda-class), 65
summary, Pca-method (Pca-class), 83
summary, Qda-method (Qda-class), 112
SummaryCov-class, 123
SummaryCovRobust-class, 124
SummaryLda-class, 125
SummaryPca-class, 126
SummaryQda-class, 127

T2.test, 128, 134

Ufunction-class (Cov-class), 11
Ulist-class (Cov-class), 11
Umatrix-class (Cov-class), 11
un86, 130
Utable-class (Cov-class), 11
Uvector-class (Cov-class), 11
wages, 131
Wilks.test, 82, 132