Package ‘edrGraphicalTools’

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Description This package comes to illustrate the articles "A graphical
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the model in SIR and SAVE approaches" and "Comparison of sliced
inverse regression approaches for underdetermined cases"
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edrGraphicalTools-package

Provides graphical tools for dimension reduction methods

Description
This package illustrates the articles listed below. It estimates by bootstrap a squared trace correlation criterion which measures the quality of the estimation of the effective dimension reduction (EDR) space. It also contains functions to perform such an estimation when the sample size is smaller than the number of explanatory variables. Methods to select the relevant explanatory variables are also included.

Details
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LazyLoad: yes

Author(s)
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References

See Also
criterionRkh, edr, plot.criterionRkh, edrSelec, edrUnderdet

Examples
## Sample generation
set.seed(10)
n <- 500
criterionRkh

Estimation of the Rkh criterion by bootstrap method

Description

This is the main function in the edrGraphicalTools package. This function estimates the square trace correlation criterion Rkh by bootstrap in order to simultaneously choose the number H of slices and the dimension K of the EDR space reduction. It creates objects of class criterionRkh. Several helper functions that require a criterionRkh object can then be applied to the output from this function.

Usage

criterionRkh(Y, X, H, K, indices, B = 50, method)
Arguments

Y  A numeric vector representing the dependent variable (a response vector).
X  A matrix representing the quantitative explanatory variables (bind by column).
H  An integer vector representing the different number of slices to be investigated.
    By default H takes integer values in 2, 3, \ldots, \text{round}(n/4); n is the sample size.
K  An integer vector representing the different dimension K to be investigated.
    By default K takes integer values in 1, 2, \ldots, \text{min}(p, 25); p is the number of
    explanatory variables.
indices  An optional integer vector specifying the indices of the bootstrap samples.
    By default, non-parametric resampling is performed. If used, an integer vector of
    length B*n will be specified; (n is the length of Y).
B  The number of bootstrap replicates. By default B equals 50.
method  This character string specifies the method of fitting. The options include "SIR-I",
    "SIR-II", and "SAVE".

Details

We are interested in the following semiparametric dimension reduction model proposed by Li
(1991)

\[ y = f(b_1'x, b_2'x, \ldots, b_K'x, e) \]

where the univariate response variable \( y \) is associated with the \( p \)-dimensional regressor \( p \) only
through the reduced \( K \)-dimensional variable \( (b_1'x, b_2'x, \ldots, b_K'x) \) with \( K < p \). The error term \( e \)
is independent of \( x \). The link function \( f \) and the \( b \)-vectors are unknown. We are interested in
finding the linear subspace spanned by the \( K \) unknown \( b \)-vector, called the effective dimension re-
duction (EDR) space. We focus on the SIR (named SIR-I), SIR-II and SAVE methods to estimate
the EDR space. The slicing step of these methods depends on the number \( H \) of slices. We propose a
naive bootstrap estimation of the square trace correlation criterion to allow selection of an “optimal”
number of slices and to simultaneously select the corresponding suitable dimension \( K \) (number of
the linear combinations of \( x \)).

Value

criterionRkh returns an object of class criterionRkh (the name of the type is the value of the
method argument), with attributes:

Rkhbootmean  A matrix corresponding of the estimation by bootstrap of the square trace crite-
    rion Rkh (h in rows and k in columns).
Rkhboot  A list including the result of the estimation of the square trace criterion for each
    bootstrap replicate.
method  the dimension reduction method used.
n  Number of subject.
H  A vector representing the different numbers H of slices investigated.
K  A vector representing the different dimensions K investigated.
indices  An vector of integers representing the indices of the bootstrap sample used.
Author(s)

Benoît Liquet, <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

References


See Also

edr, summary.criterionRkh, plot.criterionRkh

Examples

```r
## simulated example 1
set.seed(10)
n <- 500
beta <- c(1,rep(0,9))
X <- rmvnorm(n,sigma=diag(10))
eps <- rnorm(n)
y <- (X%*%beta)**3+eps*((X%*%beta)**2)
## Choice a grid of values for H
grid.H <- c(2,5,10,15,20,30)
res1 <- criterionRkh(y,X,grid.H,B=50,method="SIR-I")
res1
plot(res1,choice.H=c(2,5),choice.K=c(1,2))
## Estimation for SIR-II method with the same bootstrap replicate than for SIR-I
res2 <- criterionRkh(y,X,grid.H,indices=res1$indices,B=50,method="SIR-II")
res2
```

**edr**

*Main function for estimation of the EDR space*

**Description**

It creates objects of class edr to estimate the effective dimension regression (EDR) space. Several helper functions that require an edr object can then be applied to the output from this function.

**Usage**

`edr(Y, X, H, K, method, submethod="SIR-QZ", ...)`
Arguments

Y
A numeric vector representing the dependent variable (a response vector).

X
A matrix representing the quantitative explanatory variables (bind by column).

H
The chosen number of slices.

K
The chosen dimension k.

method
This character string specifies the method of fitting. The option includes "SIR-I", "SIR-II", and "SAVE".

submethod
This character string specifies the method of fitting when the number of lines of X is greater than its number of columns. It should be either "SIR-QZ", "RSIR" or "SR-SIR".

... Arguments to be passed to edrUnderdet when the number of lines of X is greater than its number of columns.

Details

We are interested in the following semiparametric dimension reduction model proposed by Li (1991)

\[ y = f(b_1'x, b_2'x, ..., b_K'x, e) \]

where the univariate response variable y is associated with the p-dimensional regressor p only through the reduced K-dimensional variable \((b_1'x, b_2'x, ..., b_K'x)\) with \(K < p\). The error term \(e\) is independent of \(x\). The link function \(f\) and the \(b\)-vectors are unknown. We are interested in finding the linear subspace spanned by the \(K\) unknown \(b\)-vector, called the effective dimension reduction (EDR) space. We focus on the SIR, SIR-II and SAVE methods to estimate the EDR space. The slicing step of these methods depends on the number \(H\) of slices. We propose with the function criterionRkh a naive bootstrap estimation of the square trace correlation criterion to allow selection of an “optimal” number \(H\) of slices and simultaneously the corresponding suitable dimension \(K\) (number of the linear combination of \(x\)). After choosing an optimal couple \((H, K)\) for the best estimation method (the square trace correlation criterion closest to one), the EDR space could be estimate with this function. Each method consists in a spectral decomposition of a matrix of interest. The eigenvectors of this matrix associated of the \(K\) largest eigenvalues are EDR directions.

Value

edr returns an object of class edr, with attributes:

matEDR A matrix corresponding of the eigenvectors of the interest matrix

eigvalEDR The eigenvalues of the matrix of interest

K The chosen dimension.

H The chosen number of slices.

n Sample size.

method The dimension reduction method used.

X The matrix of the quantitative explanatory variables (bind by column).

Y The numeric vector of the dependent variable (a response vector).
Author(s)

Benoît Liquet, <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

References


See Also

criterionrkh, summary.edr, plot.edr

Examples

set.seed(10)
n <- 500
beta1 <- c(1,1,rep(0,8))
beta2 <- c(0,0,1,1,rep(0,6))
X <- rmvnorm(n,sigma=diag(1,10))
eps <- rnorm(n)
Y <- (X%*%beta1)**2+(X%*%beta2)**2+eps

## Estimation of the trace square criterion
## grid.H <- c(2,5,10,15,20,30)
## res2 <- criterionrkh(Y,X,H=grid.H,B=50,method="SIR-II")
## summary(res2)
## plot(res2)

## Estimation of the EDR direction for K=2 and H=2 and SIR-II method
edr2 <- edr(Y,X,H=2,K=2,method="SIR-II")
summary(edr2)
plot(edr2)

edrSelec

Variable selection based on sliced inverse regression

Description

Gathers several procedures to determine which explanatory variables have an effect on a dependent variable. Works whether there are more explanatory variables than observations or not. Creates an object of class edrSelec.
Usage

edrSelec(Y, X, H, K, method, pZero=NULL, NZero=NULL, zeta=NULL, rho=NULL, baseEst=NULL, btspsamp=NULL, lassoParam=NULL)

Arguments

Y
A numeric vector representing the dependent variable (a response vector).

X
A matrix representing the quantitative explanatory variables (bind by column).

H
When method="SR-SIR" or method="RSIR", the chosen number of slices. When method="CSS", a vector with various numbers of slices.

K
The chosen dimension K.

method
This character string specifies the selection method. It should be either "CSS", "RSIR" or "SR-SIR".

pZero
When method="CSS", the number of variables to pick when creating a submodel.

NZero
When method="CSS", the number of submodels to create.

zeta
When method="CSS", the proportion of 'best' submodels selected from the NZero submodels.

rho
When method="CSS", and if zeta is not provided, the threshold above which a submodel is considered as 'best'. It must be a real in ]0,1[.

baseEst
An initial estimate of the EDR space on which each method relies.

btspsamp
When method="RSIR", the bootstrap sample size for estimating the asymptotic distribution of the estimated EDR directions.

lassoParam
When method="SR-SIR", a vector of lasso parameters from which the optimal one is chosen, using the RIC criterion.

Details

The "CSS" method builds NZero submodels using only pZero explanatory variables. It estimates the indices for each of them. The squared correlation between these indices and those found with the whole set of explanatory variables is computed. Only the submodels with the highest squared correlation are kept. The method then counts how many times each explanatory variable appears in these 'best' submodels. The "RSIR" procedure uses an asymptotic test on each element of the estimated EDR directions. It was translated from a Matlab code made by Peng Zeng. The "SR-SIR" procedure relies on a lasso penalty. The underlying parameter is chosen using the residual information criterion (RIC). It was written using a R code made by Lexin Li. See also http://www4.stat.ncsu.edu/~li/software.html.

Value

edrSelec returns an object of class edrSelec, with some of the following attributes, depending on the value of method:

scoreVar
A numeric vector filled with a score for each explanatory variable. Variables that have a high score should be kept. For the "CSS" method, the score is the
presence of the variable in the 'best' submodels. For "RSIR", it is one minus the
p-value of the test. For the "SR-SIR" procedure, it is a boolean that indicates if
the variable should be kept when using the optimal lasso parameter.

K
The chosen dimension.

H
The chosen number(s) of slices.

n
The sample size.

method
The variable selection method used.

X
The matrix of the quantitative explanatory variables (bind by column).

Y
The numeric vector of the dependent variable (a response vector).

matModels
A NZero x pZero matrix that contains the variables of each created submodel,
for the "CSS" method.

matModTop
A matrix with pZero columns made of the variables of each 'best' submodel,
for the "CSS" method.

vectSqCor
A vector containing the squared correlation between indices for each submodel,
for the "CSS" method.

aic
A vector made of values of the Akaïke information criterion for every lasso
parameter considered by the "SR-SIR" procedure.

bic
A vector made of values of the Bayesian information criterion for every lasso
parameter considered by the "SR-SIR" procedure.

ric
A vector made of values of the residual information criterion for every lasso
parameter considered by the "SR-SIR" procedure.

matEDR
A list which gives, for each lasso parameter studied with the "SR-SIR" proce-
dure, a matrix spanning the estimated EDR space.

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Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

References

Coudret, R., Liquet, B. and Saracco, J. Comparison of sliced inverse regression approaches for
underdetermined cases. Journal de la Société Française de Statistique, in press.


See Also

edr, edrUnderdet
Examples

```r
n <- 100
p <- 110
K <- 1
H <- 5:12
NZero <- 1000
pZero <- 10
zeta <- 0.1
beta <- c(1,1,1,1,rep(0,p-4))
U <- matrix(runif(p^2,-0.05,0.05),ncol=p)
X <- rmvnorm(n,sigma=diag(p) + U %*% t(U))
eps <- rnorm(n,sd=10)
Y <- (X*x*beta)^3*eps
result <- edrSelect(Y,X,H,K,"CSS",NZero=NZero, pZero=pZero, zeta=zeta)
summary(result)
plot(result)
```

**edrUnderdet**

**EDR space estimation for underdetermined cases.**

**Description**

Gathers several procedures to estimate the effective dimension regression (EDR) space when the number of explanatory variables is greater than the sample size. Creates an object of class edr.

**Usage**

```r
edrUnderdet(Y, X, H, K, method, initEDR=NULL, maxIter=NULL,
regulParam=NULL, sMin=1e-16, sChg=10, btspsamp=NULL)
```

**Arguments**

- **Y**
  A numeric vector representing the dependent variable (a response vector).
- **X**
  A matrix representing the quantitative explanatory variables (bind by column).
- **H**
  When `method="SR-SIR"` or `method="RSIR"`, the chosen number of slices. When `method="SIR-QZ"`, a vector with various numbers of slices.
- **K**
  The chosen dimension K.
- **method**
  This character string specifies the method of fitting. It should be either "SIR-QZ", "RSIR" or "SR-SIR".
- **initEDR**
  When `method="SR-SIR"`, a p x K matrix which contains initial values for the iterative algorithm that estimates EDR directions.
- **maxIter**
  When `method="SR-SIR"`, a maximum number of iterations after which the algorithm stops.
- **regulParam**
  When `method="SR-SIR"` or `method="RSIR"`, a vector containing possible values of the regularization parameter, from which the optimal one will be chosen.
sMin
When method="SIR-QZ", the smallest regularization parameter to test.

sChg
When method="SIR-QZ", a positive real by which a regularization parameter is multiplied to produce the next one to consider.

btspsamp
When method="RSIR", the bootstrap sample size for estimating the mean squared error.

Details
The "SIR-QZ" method estimates the indices rather than the EDR directions. It makes use of several estimations from several numbers of slices. It tries to find a minimal regularization of the covariance matrix of X. The "RSIR" procedure uses a bootstrap estimator of the mean squared error of regularized estimates of the EDR directions. It was translated from a Matlab code made by Peng Zeng. The "SR-SIR" procedure relies on a generalized cross-validation criterion and on an alternating least squares algorithm to find an optimal regularization parameter. It was written using a R code made by Lexin Li. See also http://www4.stat.ncsu.edu/~li/software.html.

Value
edrUnderdet returns an object of class edr, with some of the following attributes, depending on the value of method:

matEDR
A matrix spanning the estimated EDR space.

indices
The estimated indices from the "SIR-QZ" method.

eigvalEDR
The eigenvalues of a matrix of interest.

K
The chosen dimension.

H
The chosen number(s) of slices.

n
The sample size.

method
The dimension reduction method used.

X
The matrix of the quantitative explanatory variables (bind by column).

Y
The numeric vector of the dependent variable (a response vector).

s
The optimal regularization parameter(s) found by the chosen method.

estMSE
For each tested regularization parameter, the estimated mean squared error from the "RSIR" method.

testedEDR
For each tested regularization parameter, a matrix spanning the estimated EDR space from the "SR-SIR" method.

iter
For each tested regularization parameter, the number of iterations needed for the alternating least squares algorithm from the "SR-SIR" method to converge.

gcv
For each tested regularization parameter, the corresponding generalized cross-validation criterion from the "SR-SIR" method.

Author(s)
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plot.criterionRkh

References


See Also

`edr`, `sliceMat`

Examples

```r
n <- 100
p <- 200
K <- 2
H <- 3.8
beta1 <- c(1,1,1,1,rep(0,p-4))
beta2 <- c(rep(0,p-4), 1,1,1,1)
X <- rmvnorm(n,sigma=diag(p))
eps <- rnorm(n,sd=10)
Y <- (X%*%beta1)^3 + (X%*%beta2)^3+eps
result <- edrUnderdet(Y,X,H,K,"SIR-QZ")
summary(result)
plot(result)
```

Graphical tools for the bootstrap criterion

Description

We propose a 3D-graphical tool which can be useful to select the suitable couple (H,K). We also add some boxplots of the distribution of the bootstrap criterion.

Usage

```r
## S3 method for class 'criterionRkh'
plot(x, choice.H, choice.K, ...)
```
Arguments

x The name of an object of class criterionRkh.
choice.H An optional integer vector specifying the values of H for which a boxplot of the distribution of the bootstrap criterion is plotted for all the values of K specified in the criterionRkh object. The values of choice.H must be included in the values of H specified in the criterionRkh object.
choice.K An optional integer vector specifying the values of K for which a boxplot of the distribution of the bootstrap criterion is plotted for all the values of H specified in the criterionRkh object. The values of choice.K must be included in the values of K specified in the criterionRkh object.

... Some methods for this generic require additional arguments. None are used in this method.

Value

Returns graphs.

Author(s)

Benoît Liquet, <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

References


See Also

criterionRkh

Examples

## see example in function criterionRkh

---

plot.edr Basic plot of an edr object

Description

For an edr object with attributes K <= 2, this function plots the response y versus each new estimate indice with an estimation of the link function. For K = 2, a 3D plot of y versus the two estimate indices is represented. A smooth estimate of the link function is also represented. For K > 2, the pairs function is used.
Usage

## S3 method for class 'edr'
plot(x, ...)

Arguments

- `x` The name of an object of class `edr`.
- `...` Some methods for this generic require additional arguments. None are used in this method.

Value

Returns graphs.

Author(s)

Benoît Liquet, <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

See Also

- `summary.edr`

Examples

```r
## simulated example
set.seed(10)
n <- 500
beta1 <- c(1,1,rep(0,8))
beta2 <- c(0,0,1,1,rep(0,6))
X <- rmvnorm(n,sigma=diag(1,10))
eps <- rnorm(n)
Y <- (X*X%*%beta1)**2+(X*X%*%beta2)**2+eps
edr2 <- edr(Y,X,H=2,K=2,method="SIR-II")
plot(edr2)
## edr4 <- edr(Y,X,H=2,K=4,method="SIR-II")
## plot(edr4)
```

---

### Description

Methods to present the results of a variable selection procedure based on slice inverse regression.
print.criterionRkh

Usage

```r
## S3 method for class 'edrSelec'
print(x, ...)
## S3 method for class 'edrSelec'
summary(object, nVar=5, ...)
## S3 method for class 'edrSelec'
plot(x, nVar=25, ...)
```

Arguments

- `x`: An object of class edrSelec generated by the function `edrSelec`.
- `object`: An object of class edrSelec generated by the function `edrSelec`.
- `nVar`: If `nVar`!=NULL, the method will only show the `nVar` most important variables with respect to the criterion computed by the function `edrSelec`. Not implemented for the `summary` method when executed with a "SR-SIR" procedure.
- `...`: Other unused parameters.

Value

These methods display (with a text or a graphic) the score of each considered variable. The user should keep the variables with a high score.

Author(s)

Raphaël Coudret <rcoudret@gmail.com>, Benoît Liquet <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

See Also

`edrSelec`, `edrUnderdet`, `edr`

Examples

```r
## see the example of the function edrSelec.
```

---

**print.criterionRkh**  
*Print a Summary of a criterionRkh Object*

Description

This is a method for the function print for objects of the class criterionRkh.

Usage

```r
## S3 method for class 'criterionRkh'
print(x, ...)
```
Arguments

x An object of class criterionRkh generated by the function criterionRkh.

... Further arguments passed to or from other methods.

Value

A summary of the criterionRkh Object is returned.

Author(s)

Benoît Liquet, <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

See Also

criterionRkh

---

print.edr  
Print a Summary of an edr Object

Description

This is a method for the function print for objects of the class edr.

Usage

```r
## S3 method for class 'edr'
print(x, ...)
```

Arguments

x An object of class edr generated by the function edr.

... Further arguments to be passed to or from other methods. They are ignored in this function

Value

A summary of the edr Object is returned.

Author(s)

Benoît Liquet, <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

See Also

edr
sliceMat

Slicing matrix computation

Description

Returns the slicing matrix required for the "SIR-I" method.

Usage

sliceMat(Y, X, H, details=FALSE, rdSup=FALSE)

Arguments

Y  A numeric vector representing the dependent variable (a response vector).
X  A matrix representing the quantitative explanatory variables (bind by column).
H  The chosen number of slices.
details  A boolean that determines whether or not some matrices used to construct the slicing matrix should be sent back. See also 'Value'.
rdSup  When the number of slices is not a divisor of the sample size, this boolean determines whether or not the slices which contain an extra point are randomly chosen.

Details

This function divides the range of Y in H distinct intervals, or slices. It then puts every row of X into a slice with respect to the corresponding element of Y. It finally computes a matrix $M = X_h' P_h X_h$ where each row of $X_h$ is the mean vector over the vectors of X that belong to a given slice. The matrix $P_h$ is diagonal and contains the number of rows of X placed in each sliced. The matrix $M$ is required when trying to perform a sliced inverse regression.

Value

If details=FALSE, the $p \times p$ slicing matrix $M$, where $p$ is the number of columns of X.
If details=TRUE, a list made of $M$, $X_h$ and $P_h$.

Author(s)

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See Also

edr, edrUnderdet
Examples

```r
# The "SIR-I" method without using 'edr'

n <- 500
p <- 5
H <- 10
beta <- c(1, 1, 1, 0, 0)
X <- rmvnorm(n, rep(0, p), diag(p))
eps <- rnorm(n, 0, 10)
Y <- (X %*% beta)^3 + eps
M <- sliceMat(Y, X, H)
hatBeta <- eigen(solve(var(X)) %*% M)$vectors[,1]
cor(hatBeta, beta)^2
```

---

**summary.criterionRkh**  
*Print a Summary of a criterionRkh Object*

**Description**

This is a method for the function `summary` for objects of the class `criterionRkh`.

**Usage**

```r
## S3 method for class 'criterionRkh'
summary(object, ...)  
```

**Arguments**

- `object`  
  An object of class `criterionRkh` generated by the function `criterionRkh`.  

- `...`  
  Further arguments passed to or from other methods.

**Value**

A summary of the `criterionRkh` Object is returned.

**Author(s)**

Benoît Liquet, <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

**See Also**

- `criterionRkh`
**summary.edr**

*Print a Summary of an edr Object*

**Description**

This is a method for the function `summary` for objects of the class `edr`.

**Usage**

```r
## S3 method for class 'edr'
summary(object, ...)  
```

**Arguments**

- `object` An object of class `edr` generated by the function `edr`.
- `...` further arguments passed to or from other methods.

**Value**

A summary of the `edr` Object is returned.

**Author(s)**

Benoît Liquet, <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

**See Also**

- `edr`
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