Package ‘ccaPP’

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Type Package
Title (Robust) Canonical Correlation Analysis via Projection Pursuit
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Date 2016-03-07
Depends R (>= 3.2.0), parallel, pcaPP (>= 1.8-1), robustbase
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LinkingTo Rcpp (>= 0.11.0), RcppArmadillo (>= 0.4.100.0)
Suggests knitr, mvtnorm
VignetteBuilder knitr
Description Canonical correlation analysis and maximum correlation via projection pursuit, as well as fast implementations of correlation estimators, with a focus on robust and non-parametric methods.
License GPL (>= 2)
LazyLoad yes
Author Andreas Alfons [aut, cre], David Simcha [ctb]
Maintainer Andreas Alfons <alfons@ese.eur.nl>
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Description

Canonical correlation analysis and maximum correlation via projection pursuit, as well as fast implementations of correlation estimators, with a focus on robust and non-parametric methods.

Details

The DESCRIPTION file:

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Suggests: knitr, mvtnorm
VignetteBuilder: knitr
Description: Canonical correlation analysis and maximum correlation via projection pursuit, as well as fast implementations of correlation estimators
License: GPL (> = 2)
LazyLoad: yes
Authors@R: c(person("Andreas", "Alfons", email = "alfons@ese.eur.nl", role = c("aut", "cre")), person("David", "Simcha"), person("Simcha", "David", role = c("ctb")))
Author: Andreas Alfons [aut, cre], David Simcha [ctb]
Maintainer: Andreas Alfons <alfons@ese.eur.nl>

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    deviation
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maxCorGrid         (Robust) maximum correlation via alternating
                  series of grid searches
maxCorProj         (Robust) maximum correlation via projections
                  through the data points
permTest           (Robust) permutation test for no association

Author(s)

Andreas Alfons [aut, cre], David Simcha [ctb]
Maintainer: Andreas Alfons <alfons@ese.eur.nl>

References

A. Alfons, C. Croux and P. Filzmoser (2016) Robust maximum association between data sets: The
A. Alfons, C. Croux and P. Filzmoser (2016) Robust maximum association estimators. Journal of

ccaGrid            (Robust) CCA via alternating series of grid searches

Description

Perform canonical correlation analysis via projection pursuit based on alternating series of grid
searches in two-dimensional subspaces of each data set, with a focus on robust and nonparametric
methods.

Usage

ccaGrid(x, y, k = 1, method = c("spearman", "kendall", "quadrant", "M", "pearson"),
        control = list(...), nIterations = 10, nAlternate = 10,
        nGrid = 25, select = NULL, tol = 1e-06, standardize = TRUE,
        fallback = FALSE, seed = NULL, ...)

CCAgird(x, y, k = 1, method = c("spearman", "kendall", "quadrant", "M", "pearson"),
        maxiter = 10, maxalter = 10, splitcircle = 25,
        select = NULL, zero.tol = 1e-06, standardize = TRUE, fallback = FALSE,
        seed = NULL, ...)

Arguments

  x, y                      each can be a numeric vector, matrix or data frame.
  k                         an integer giving the number of canonical variables to compute.
method a character string specifying the correlation functional to maximize. Possible values are "spearman" for the Spearman correlation, "kendall" for the Kendall correlation, "quadrant" for the quadrant correlation, "M" for the correlation based on a bivariate M-estimator of location and scatter with a Huber loss function, or "pearson" for the classical Pearson correlation (see corFunctions).

control a list of additional arguments to be passed to the specified correlation functional. If supplied, this takes precedence over additional arguments supplied via the ... argument.

nIterations,maxiter an integer giving the maximum number of iterations.

nAlternate,maxalter an integer giving the maximum number of alternate series of grid searches in each iteration.

nGrid,splitcircle an integer giving the number of equally spaced grid points on the unit circle to use in each grid search.

select optional; either an integer vector of length two or a list containing two index vectors. In the first case, the first integer gives the number of variables of x to be randomly selected for determining the order of the variables of y in the corresponding series of grid searches, and vice versa for the second integer. In the latter case, the first list element gives the indices of the variables of x to be used for determining the order of the variables of y, and vice versa for the second integer (see “Details”).

tol,zero.tol a small positive numeric value to be used for determining convergence.

standardize a logical indicating whether the data should be (robustly) standardized.

fallback logical indicating whether a fallback mode for robust standardization should be used. If a correlation functional other than the Pearson correlation is maximized, the first attempt for standardizing the data is via median and MAD. In the fallback mode, variables whose MADs are zero (e.g., dummy variables) are standardized via mean and standard deviation. Note that if the Pearson correlation is maximized, standardization is always done via mean and standard deviation.

seed optional initial seed for the random number generator (see .Random.seed). This is only used if select specifies the numbers of variables of each data set to be randomly selected for determining the order of the variables of the respective other data set.

... additional arguments to be passed to the specified correlation functional. Currently, this is only relevant for the M-estimator. For Spearman, Kendall and quadrant correlation, consistency at the normal model is always forced.

Details

The algorithm is based on alternating series of grid searches in two-dimensional subspaces of each data set. In each grid search, nGrid grid points on the unit circle in the corresponding plane are obtained, and the directions from the center to each of the grid points are examined. In the first iteration, equispaced grid points in the interval \([-\pi/2, \pi/2)\) are used. In each subsequent iteration, the angles are halved such that the interval \([-\pi/4, \pi/4)\) is used in the second iteration and so
on. If only one data set is multivariate, the algorithm simplifies to iterative grid searches in two-dimensional subspaces of the corresponding data set.

In the basic algorithm, the order of the variables in a series of grid searches for each of the data sets is determined by the average absolute correlations with the variables of the respective other data set. Since this requires to compute the full \((p \times q)\) matrix of absolute correlations, where \(p\) denotes the number of variables of \(x\) and \(q\) the number of variables of \(y\), a faster modification is available as well. In this modification, the average absolute correlations are computed over only a subset of the variables of the respective other data set. It is thereby possible to use randomly selected subsets of variables, or to specify the subsets of variables directly.

Note that also the data sets are ordered according to the maximum average absolute correlation with the respective other data set to ensure symmetry of the algorithm.

For higher order canonical correlations, the data are first transformed into suitable subspaces. Then the alternate grid algorithm is applied to the reduced data and the results are back-transformed to the original space.

Value

An object of class "cca" with the following components:

- cor: a numeric vector giving the canonical correlation measures.
- A: a numeric matrix in which the columns contain the canonical vectors for \(x\).
- B: a numeric matrix in which the columns contain the canonical vectors for \(y\).
- centerX: a numeric vector giving the center estimates used in standardization of \(x\).
- centerY: a numeric vector giving the center estimates used in standardization of \(y\).
- scaleX: a numeric vector giving the scale estimates used in standardization of \(x\).
- scaleY: a numeric vector giving the scale estimates used in standardization of \(y\).
- call: the matched function call.

Note

CCAgrid is a simple wrapper function for ccaGrid for more compatibility with package pcaPP concerning function and argument names.

Author(s)

Andreas Alfons

See Also

ccaProj, maxCorGrid, corFunctions
Examples

data("diabetes")
x <- diabetes$x
y <- diabetes$y

## Spearman correlation
ccaGrid(x, y, method = "spearman")

## Pearson correlation
ccaGrid(x, y, method = "pearson")

ccaProj

(Robust) CCA via projections through the data points

Description

Perform canonical correlation analysis via projection pursuit based on projections through the data points, with a focus on robust and nonparametric methods.

Usage

ccaProj(x, y, k = 1, method = c("spearman", "kendall", "quadrant", "M", "pearson"), control = list(...), standardize = TRUE, useL1Median = TRUE, fallback = FALSE, ...)

CCAproj(x, y, k = 1, method = c("spearman", "kendall", "quadrant", "M", "pearson"), standardize = TRUE, useL1Median = TRUE, fallback = FALSE, ...)

Arguments

x, y each can be a numeric vector, matrix or data frame.
k an integer giving the number of canonical variables to compute.
method a character string specifying the correlation functional to maximize. Possible values are "spearman" for the Spearman correlation, "kendall" for the Kendall correlation, "quadrant" for the quadrant correlation, "M" for the correlation based on a bivariate M-estimator of location and scatter with a Huber loss function, or "pearson" for the classical Pearson correlation (see corFunctions).
control a list of additional arguments to be passed to the specified correlation functional. If supplied, this takes precedence over additional arguments supplied via the ... argument.
standardize a logical indicating whether the data should be (robustly) standardized.
useL1Median a logical indicating whether the $L_1$ medians should be used as the centers of the data sets in standardization (defaults to TRUE). If FALSE, the columnwise centers are used instead (columnwise means if method is "pearson" and columnwise medians otherwise).
logical indicating whether a fallback mode for robust standardization should be used. If a correlation functional other than the Pearson correlation is maximized, the first attempt for standardizing the data is via median and MAD. In the fallback mode, variables whose MADs are zero (e.g., dummy variables) are standardized via mean and standard deviation. Note that if the Pearson correlation is maximized, standardization is always done via mean and standard deviation.

... additional arguments to be passed to the specified correlation functional. Currently, this is only relevant for the M-estimator. For Spearman, Kendall and quadrant correlation, consistency at the normal model is always forced.

Details

First the candidate projection directions are defined for each data set from the respective center through each data point. Then the algorithm scans all $n^2$ possible combinations for the maximum correlation, where $n$ is the number of observations.

For higher order canonical correlations, the data are first transformed into suitable subspaces. Then the alternate grid algorithm is applied to the reduced data and the results are back-transformed to the original space.

Value

An object of class "cca" with the following components:

- `cor` a numeric vector giving the canonical correlation measures.
- `A` a numeric matrix in which the columns contain the canonical vectors for $x$.
- `B` a numeric matrix in which the columns contain the canonical vectors for $y$.
- `centerX` a numeric vector giving the center estimates used in standardization of $x$.
- `centerY` a numeric vector giving the center estimates used in standardization of $y$.
- `scaleX` a numeric vector giving the scale estimates used in standardization of $x$.
- `scaleY` a numeric vector giving the scale estimates used in standardization of $y$.
- `call` the matched function call.

Note

CCAproj is a simple wrapper function for ccaProj for more compatibility with package pcaPP concerning function names.

Author(s)

Andreas Alfons

See Also

ccaGrid, maxCorProj, corFunctions
Examples

data("diabetes")
x <- diabetes$x
y <- diabetes$y

## Spearman correlation
ccaProj(x, y, method = "spearman")

## Pearson correlation
ccaProj(x, y, method = "pearson")

corFunctions

Fast implementations of (robust) correlation estimators

Description

Estimate the correlation of two vectors via fast C++ implementations, with a focus on robust and nonparametric methods.

Usage

corPearson(x, y)

corSpearman(x, y, consistent = FALSE)

corKendall(x, y, consistent = FALSE)

corQuadrant(x, y, consistent = FALSE)

corM(x, y, prob = 0.9, initial = c("quadrant", "spearman", "kendall", "pearson"), tol = 1e-06)

Arguments

x, y numeric vectors.
consistent a logical indicating whether a consistent estimate at the bivariate normal distribution should be returned (defaults to FALSE).
prob numeric; probability for the quantile of the $\chi^2$ distribution to be used for tuning the Huber loss function (defaults to 0.9).
initial a character string specifying the starting values for the Huber M-estimator. For "quadrant" (the default), "spearman" or "kendall", the consistent version of the respecive correlation measure is used together with the medians and MAD's. For "pearson", the Pearson correlation is used together with the means and standard deviations.
tol a small positive numeric value to be used for determining convergence.
Details

corPearson estimates the classical Pearson correlation. corSpearman, corKendall and corQuadrant estimate the Spearman, Kendall and quadrant correlation, respectively, which are nonparametric correlation measures that are somewhat more robust. corM estimates the correlation based on a bivariate M-estimator of location and scatter with a Huber loss function, which is sufficiently robust in the bivariate case, but loses robustness with increasing dimension.

The nonparametric correlation measures do not estimate the same population quantities as the Pearson correlation, the latter of which is consistent at the bivariate normal model. Let \( \rho \) denote the population correlation at the normal model. Then the Spearman correlation estimates \((6/\pi) \arcsin(\rho/2)\), while the Kendall and quadrant correlation estimate \((2/\pi) \arcsin(\rho)\). Consistent estimates are thus easily obtained by taking the corresponding inverse expressions.

The Huber M-estimator, on the other hand, is consistent at the bivariate normal model.

Value

The respective correlation estimate.

Note

The Kendall correlation uses a naive \( n^2 \) implementation if \( n < 30 \) and a fast \( O(n \log(n)) \) implementation for larger values, where \( n \) denotes the number of observations.

Functionality for removing observations with missing values is currently not implemented.

Author(s)

Andreas Alfons, \( O(n \log(n)) \) implementation of the Kendall correlation by David Simcha

See Also

ccaGrid, ccaProj.cor

Examples

```r
## generate data
library("mvtnorm")
set.seed(1234)  # for reproducibility
sigma <- matrix(c(1, 0.6, 0.6, 1), 2, 2)
xy <- rmvnorm(100, sigma=sigma)
x <- xy[, 1]
y <- xy[, 2]

## compute correlations

# Pearson correlation
corPearson(x, y)

# Spearman correlation
corSpearman(x, y)
corSpearman(x, y, consistent=TRUE)
```
# Kendall correlation
corkKendall(x, y)
corkKendall(x, y, consistent=TRUE)

# quadrant correlation
corQuadrant(x, y)
corQuadrant(x, y, consistent=TRUE)

# Huber M-estimator
corM(x, y)

diabetes  

*Diabetes data*

**Description**

Subset of the diabetes data from Andrews & Herzberg (1985).

**Usage**

data(diabetes)

**Format**

A list with components `x` and `y`. Both components are matrices with observations on different variables for the same $n = 76$ persons.

Component `x` is a matrix containing the following $p = 2$ variables.

- RelativeWeight relative weight.
- PlasmaGlucose fasting plasma glucose.

Component `y` is a matrix containing the following $q = 3$ variables.

- GlucoseIntolerance glucose intolerance.
- InsulinResponse insulin response to oral glucose.
- InsulinResistance insulin resistance.

**Source**

Examples

```r
data("diabetes")
x <- diabetes$x
y <- diabetes$y

## Spearman correlation
maxCorGrid(x, y, method = "spearman")
maxCorGrid(x, y, method = "spearman", consistent = TRUE)

## Pearson correlation
maxCorGrid(x, y, method = "pearson")
```

Description

Compute the median absolute deviation with a fast C++ implementation. By default, a multiplication factor is applied for consistency at the normal model.

Usage

`fastMAD(x, constant = 1.4826)`

Arguments

- `x`: a numeric vector.
- `constant`: a numeric multiplication factor. The default value yields consistency at the normal model.

Value

A list with the following components:

- `center`: a numeric value giving the sample median.
- `mad`: a numeric value giving the median absolute deviation.

Note

Functionality for removing observations with missing values is currently not implemented.

Author(s)

Andreas Alfons

See Also

`fastMedian`, `mad`
Examples

```r
set.seed(1234)  # for reproducibility
x <- rnorm(100)
fastMedian(x)
```

---

**Description**

Compute the sample median with a fast C++ implementation.

**Usage**

```r
fastMedian(x)
```

**Arguments**

- `x`  
a numeric vector.

**Value**

The sample median.

**Note**

Functionality for removing observations with missing values is currently not implemented.

**Author(s)**

Andreas Alfons

**See Also**

`fastMAD`, `median`

**Examples**

```r
set.seed(1234)  # for reproducibility
x <- rnorm(100)
fastMedian(x)
```
maxCorGrid

(Robust) maximum correlation via alternating series of grid searches

Description

Compute the maximum correlation between two data sets via projection pursuit based on alternating series of grid searches in two-dimensional subspaces of each data set, with a focus on robust and nonparametric methods.

Usage

maxCorGrid(x, y, method = c("spearman", "kendall", "quadrant", "M", "pearson"), control = list(...), nIterations = 10, nAlternate = 10, nGrid = 25, select = NULL, tol = 1e-06, standardize = TRUE, fallback = FALSE, seed = NULL, ...)

Arguments

x, y each can be a numeric vector, matrix or data frame.
method a character string specifying the correlation functional to maximize. Possible values are "spearman" for the Spearman correlation, "kendall" for the Kendall correlation, "quadrant" for the quadrant correlation, "M" for the correlation based on a bivariate M-estimator of location and scatter with a Huber loss function, or "pearson" for the classical Pearson correlation (see corFunctions).
control a list of additional arguments to be passed to the specified correlation functional. If supplied, this takes precedence over additional arguments supplied via the ... argument.
nIterations an integer giving the maximum number of iterations.
nAlternate an integer giving the maximum number of alternate series of grid searches in each iteration.
nGrid an integer giving the number of equally spaced grid points on the unit circle to use in each grid search.
select optional; either an integer vector of length two or a list containing two index vectors. In the first case, the first integer gives the number of variables of x to be randomly selected for determining the order of the variables of y in the corresponding series of grid searches, and vice versa for the second integer. In the latter case, the first list element gives the indices of the variables of x to be used for determining the order of the variables of y, and vice versa for the second integer (see "Details").
tol a small positive numeric value to be used for determining convergence.
standardize a logical indicating whether the data should be (robustly) standardized.
fallback logical indicating whether a fallback mode for robust standardization should be used. If a correlation functional other than the Pearson correlation is maximized,
the first attempt for standardizing the data is via median and MAD. In the fall-back mode, variables whose MADs are zero (e.g., dummy variables) are standardized via mean and standard deviation. Note that if the Pearson correlation is maximized, standardization is always done via mean and standard deviation.

```
seed
```

optional initial seed for the random number generator (see `Random.seed`). This is only used if `select` specifies the numbers of variables of each data set to be randomly selected for determining the order of the variables of the respective other data set.

```
...
```

additional arguments to be passed to the specified correlation functional.

Details

The algorithm is based on alternating series of grid searches in two-dimensional subspaces of each data set. In each grid search, `nGrid` grid points on the unit circle in the corresponding plane are obtained, and the directions from the center to each of the grid points are examined. In the first iteration, equispaced grid points in the interval \([-\pi/2, \pi/2)\) are used. In each subsequent iteration, the angles are halved such that the interval \([-\pi/4, \pi/4)\) is used in the second iteration and so on. If only one data set is multivariate, the algorithm simplifies to iterative grid searches in two-dimensional subspaces of the corresponding data set.

In the basic algorithm, the order of the variables in a series of grid searches for each of the data sets is determined by the average absolute correlations with the variables of the respective other data set. Since this requires to compute the full \((p \times q)\) matrix of absolute correlations, where \(p\) denotes the number of variables of \(x\) and \(q\) the number of variables of \(y\), a faster modification is available as well. In this modification, the average absolute correlations are computed over only a subset of the variables of the respective other data set. It is thereby possible to use randomly selected subsets of variables, or to specify the subsets of variables directly.

Note that also the data sets are ordered according to the maximum average absolute correlation with the respective other data set to ensure symmetry of the algorithm.

Value

An object of class "maxCor" with the following components:

- `cor` a numeric giving the maximum correlation estimate.
- `a` numeric; the weighting vector for \(x\).
- `b` numeric; the weighting vector for \(y\).
- `centerX` a numeric vector giving the center estimates used in standardization of \(x\).
- `centerY` a numeric vector giving the center estimates used in standardization of \(y\).
- `scaleX` a numeric vector giving the scale estimates used in standardization of \(x\).
- `scaleY` a numeric vector giving the scale estimates used in standardization of \(y\).
- `call` the matched function call.

Author(s)

Andreas Alfons
maxCorProj

References


See Also

maxCorProj, ccaGrid, corFunctions

Examples

data("diabetes")
x <- diabetes$x
y <- diabetes$y

## Spearman correlation
maxCorGrid(x, y, method = "spearman")
maxCorGrid(x, y, method = "spearman", consistent = TRUE)

## Pearson correlation
maxCorGrid(x, y, method = "pearson")

Description

Compute the maximum correlation between two data sets via projection pursuit based on projections through the data points, with a focus on robust and nonparametric methods.

Usage

maxCorProj(x, y, method = c("spearman", "kendall", "quadrant", "M", "pearson"), control = list(...), standardize = TRUE, useL1Median = TRUE, fallback = FALSE, ...)

Arguments

x, y each can be a numeric vector, matrix or data frame.

method a character string specifying the correlation functional to maximize. Possible values are "spearman" for the Spearman correlation, "kendall" for the Kendall correlation, "quadrant" for the quadrant correlation, "M" for the correlation based on a bivariate M-estimator of location and scatter with a Huber loss function, or "pearson" for the classical Pearson correlation (see corFunctions).

control a list of additional arguments to be passed to the specified correlation functional. If supplied, this takes precedence over additional arguments supplied via the ... argument.
**maxCorProj**

`standardize` a logical indicating whether the data should be (robustly) standardized.

`useL1Median` a logical indicating whether the $L_1$ medians should be used as the centers of the data sets in standardization (defaults to TRUE). If FALSE, the columnwise centers are used instead (columnwise means if method is "pearson" and columnwise medians otherwise).

`fallback` logical indicating whether a fallback mode for robust standardization should be used. If a correlation functional other than the Pearson correlation is maximized, the first attempt for standardizing the data is via median and MAD. In the fallback mode, variables whose MADs are zero (e.g., dummy variables) are standardized via mean and standard deviation. Note that if the Pearson correlation is maximized, standardization is always done via mean and standard deviation.

`...` additional arguments to be passed to the specified correlation functional.

**Details**

First the candidate projection directions are defined for each data set from the respective center through each data point. Then the algorithm scans all $n^2$ possible combinations for the maximum correlation, where $n$ is the number of observations.

**Value**

An object of class "maxCor" with the following components:

- `cor` a numeric giving the maximum correlation estimate.
- `a` numeric; the weighting vector for $x$.
- `b` numeric; the weighting vector for $y$.
- `centerX` a numeric vector giving the center estimates used in standardization of $x$.
- `centerY` a numeric vector giving the center estimates used in standardization of $y$.
- `scaleX` a numeric vector giving the scale estimates used in standardization of $x$.
- `scaleY` a numeric vector giving the scale estimates used in standardization of $y$.
- `call` the matched function call.

**Author(s)**

Andreas Alfons

**See Also**

`maxCorGrid, ccaProj, corFunctions`

**Examples**

```r
data("diabetes")
x <- diabetes$x
y <- diabetes$y

## Spearman correlation```
permTest

maxCorProj(x, y, method = "spearman")
maxCorProj(x, y, method = "spearman", consistent = TRUE)

## Pearson correlation
maxCorProj(x, y, method = "pearson")

permTest  (Robust) permutation test for no association

Description
Test whether or not there is association between two data sets, with a focus on robust and nonparametric correlation measures.

Usage
permTest(x, y, R = 1000, fun = maxCorGrid, permutations = NULL,
nCores = 1, cl = NULL, seed = NULL, ...)

Arguments
x, y each can be a numeric vector, matrix or data frame.
R an integer giving the number of random permutations to be used.
fun a function to compute a maximum correlation measure between two data sets, e.g., maxCorGrid (the default) or maxCorProj. It should expect the data to be passed as the first and second argument, and must return an object of class "maxcor".
permutations an integer matrix in which each column contains the indices of a permutation. If supplied, this is preferred over R.
nCores a positive integer giving the number of processor cores to be used for parallel computing (the default is 1 for no parallelization). If this is set to NA, all available processor cores are used.
cl a parallel cluster for parallel computing as generated by makeCluster. If supplied, this is preferred over nCores.
seed optional integer giving the initial seed for the random number generator (see Random.seed). For parallel computing, random number streams are used rather than the standard random number generator and the seed is set via clusterSetRNGStream.
... additional arguments to be passed to fun.

Details
The test generates R data sets by randomly permuting the observations of x, while keeping the observations of y fixed. In each replication, a function to compute a maximum correlation measure is applied to the permuted data sets. The p-value of the test is then given by the percentage of replicates of the maximum correlation measure that are larger than the maximum correlation measure computed from the original data.
Value

An object of class "permTest" with the following components:

- **pValue**: the p-value for the test.
- **cor0**: the value of the test statistic.
- **cor**: the values of the test statistic for each of the permutated data sets.
- **R**: the number of random permutations.
- **seed**: the seed of the random number generator.
- **call**: the matched function call.

Author(s)

Andreas Alfons

References


See Also

*maxCorGrid, maxCorProj*

Examples

```r
data("diabetes")
x <- diabetes$x
y <- diabetes$y

# Spearman correlation
permTest(x, y, R = 100, method = "spearman")
permTest(x, y, R = 100, method = "spearman", consistent = TRUE)

# Pearson correlation
permTest(x, y, R = 100, method = "pearson")
```
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