Package ‘TestCor’

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Title FWER and FDR Controlling Procedures for Multiple Correlation Tests

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Description Different multiple testing procedures for correlation tests are implemented. These procedures were shown to theoretically control asymptotically the Family Wise Error Rate (Roux (2018) <https://tel.archives-ouvertes.fr/tel-01971574v1>) or the False Discovery Rate (Cai & Liu (2016) <doi:10.1080/01621459.2014.999157>). The package gather four test statistics used in correlation testing, four FWER procedures with either single step or stepdown versions, and four FDR procedures.

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Description

The package compiles some multiple testing procedures which theoretically control asymptotically
the FWER in the framework of correlation testing. Four tests statistics can be considered: the em-
pirical correlation, the Student statistics, the Fisher’s z-transform and the usual Gaussian statistics
considering random variables \( (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j)) \). Four methods are imple-
mented: Bonferroni (1935)’s, Šidák (1967)’s, Romano & Wolf (2005)’s bootstrap and (Drton &
Perlman (2007)’s procedure based on the asymptotic distributions of the test statistics, called Max-
Tinfty. The package also includes some multiple testing procedures which are related to the control
of the FDR: Cai & Liu (2016)’s procedures called LCT-N and LCT-B -which have been proven to
control the FDR for correlation tests- and Benjamini & Hochberg (1995)’s -which has no theoretical
results in correlation testing.

Details

Consider \{\( X_\ell = (X_{1\ell}, \ldots , X_{p\ell}) \), \( \ell = 1, \ldots , n \} \) a set of \( n \) independent and identically distributed
\( R^p \)-valued random variables. Denote data the array containing \( \{X_\ell, \ \ell = 1, \ldots , n\} \), with observation
indexes \( l \) in row. The aim is to test simultaneously

\[
(H_{0ij}) \ Cor(X_i, X_j) = 0 \text{ against } (H_{1ij}) \ Cor(X_i, X_j) \neq 0, \ i, j = 1, \ldots , p, \ i < j.
\]

Four tests statistics are implemented: the empirical correlation, the Student statistics, the Fisher’s
z-transform and the usual test statistics on expectancy considering the product of random variables.
They are available in function eval_stat. Next, two main types of procedures are available:
Asymptotically FWER controlling procedures: Bonferroni (1935)’s method, Šidák (1967)’s procedure, Romano & Wolf (2005)’s bootstrap procedure and Drton & Perlman (2007)’s procedure. A description of these methods can be found in Chapter 5 of Roux (2018). To apply these procedures, function ApplyFwerCor can be used as follows: 
\[ \text{ApplyFwerCor(data, alpha, stat_test, method)} \]
with \( \alpha \) the desired level of control for FDR and \( \text{stat_test, method} \) respectively the kind of test statistic and the FDR controlling method. The function returns the list of indexes \( \{(i, j), i < j\} \) for which null hypothesis \( H_{0ij} \) is rejected.

Asymptotically FDR controlling procedures: Cai & Liu (2016)’s two procedures and Benjamini & Hochberg (1995)’s procedure (with no theoretical proof for the latest). To apply these procedures, use function ApplyFdrCor as follows: 
\[ \text{ApplyFdrCor(data, alpha, stat_test, method)} \]
with \( \alpha \) the desired level of control for FWER and \( \text{stat_test, method} \) respectively the kind of test statistic and the FDR controlling method. The function returns the list of indexes \( \{(i, j), i < j\} \) for which null hypothesis \( H_{0ij} \) is rejected.

Functions SimuFwer and SimuFdr provide simulations of Gaussian random variables for a given correlation matrix and return estimated FWER, FDR, Power and true discovery rate obtained applying one of the procedure above. Some example of results obtained can be found in Chapter 6 of Roux (2018).

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References


Examples

# Parameters for simulations
Nsimu <- 100  # number of Monte-Carlo simulations
seqn <- seq(100, 400, 100)  # sample sizes
p <- 10  # number of random variables considered
rho <- 0.3  # value of non-zero correlations
seed <- 156724

corr_theo <- diag(1, p)  # the correlation matrix
corr_theo[1, 2:p] <- rho
corr_theo[2:p, 1] <- rho

# Parameters for multiple testing procedure
stat_test <- 'empirical'  # test statistics for correlation tests
method <- 'BootRW'  # FWER controlling procedure
SD <- FALSE  # logical determining if stepdown is applied
alpha <- 0.05  # FWER threshold
Nboot <- 100  # number of bootstrap or simulated samples

# Simulations and application of the chosen procedure
res <- matrix(0, nrow=length(seqn), ncol=5)
for(i in 1:length(seqn)){
  temp <- SimuFwer(corr_theo, n=seqn[i], Nsimu=Nsimu, alpha=alpha, stat_test=stat_test,
                     method='BootRW', Nboot=Nboot, stepdown=SD, seed=seed)
  res[i,] <- temp
}
rownames(res) <- seqn
colnames(res) <- names(temp)

# Display results
par(mfrow=c(1,2))
plot(seqn, res[, 'fwer'], type='b', ylim=c(0, max(alpha*1.1, max(res[, 'fwer']))),
     main='FWER', ylab='fwer', xlab='number of observations')
plot(seqn, res[, 'sensitivity'], type='b', ylim=c(0, 1.1),
     main='Power', ylab='sensitivity', xlab='number of observations')

ApplyFdrCor

Applies multiple testing procedures built to control (asymptotically) the FDR for correlation testing.

Description

Applies multiple testing procedures built to control (asymptotically) the FDR for correlation testing. Some have no theoretical proofs for tests on a correlation matrix.
ApplyFdrCor

Usage

ApplyFdrCor(
  data,
  alpha = 0.05,
  stat_test = "empirical",
  method = "LCTnorm",
  Nboot = 1000,
  vect = FALSE,
  arr.ind = FALSE
)

Arguments

data          matrix of observations
alpha         level of multiple testing
stat_test     'empirical' $\sqrt{n} \cdot \text{abs}(corr)$
               'fisher' $\sqrt{n - 3} \cdot 1/2 \cdot \log((1 + corr)/(1 - corr))$
               'student' $\sqrt{n - 2} \cdot \text{abs}(corr)/\sqrt{(1 - corr^2)}$
               '2nd.order' $\sqrt{n}\cdot\text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j))$
method        choice between 'LCTnorm' and 'LCTboot' developed by Cai & Liu (2016),
               'BH', traditional Benjamini-Hochberg's procedure Benjamini & Hochberg (1995)'s
               and 'BHboot', Benjamini-Hochberg (1995)'s procedure with bootstrap evaluation
               of p-values
Nboot         number of iterations for bootstrap p-values evaluation
vect          if TRUE returns a vector of TRUE/FALSE values, corresponding to vectorize(cor(data));
               if FALSE, returns an array containing rows and columns of significant correlations
arr.ind      if TRUE, returns the indexes of the significant correlations, with respect to
               level alpha

Value

Returns either

- logicals indicating if the corresponding correlation is significant, as a vector or a matrix dependent on vect,
- an array containing indexes $\{(i, j), i < j\}$ for which correlation between variables $i$ and $j$ is significant, if arr.ind=TRUE.

References


ApplyFwerCor


See Also

ApplyFwerCor

LCTnorm, LCTboot, BHCor, BHBootCor

Examples

```r
n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
data <- MASS::mvrnorm(n,rep(0,p),corr_theo)
res <- ApplyFdrCor(data,stat_test="empirical",method="LCTnorm")
# significant correlations, level alpha:
alpha <- 0.05
whichCor(res<alpha)
```

ApplyFwerCor

Applies multiple testing procedures controlling (asymptotically) the FWER for tests on a correlation matrix.

Description

Applies multiple testing procedures controlling (asymptotically) the FWER for tests on a correlation matrix. Methods are described in Chapter 5 of Roux (2018).

Usage

```r
ApplyFwerCor(
  data,
  alpha = NULL,
  stat_test = "empirical",
  method = "Sidak",
  Nboot = 1000,
  stepdown = TRUE,
  vect = FALSE,
  logical = stepdown,
  arr.ind = FALSE
)
```
ApplyFwerCor

Arguments

data matrix of observations
alpha level of multiple testing (used if logical=TRUE)
stat_test 'empirical' $\sqrt{n} \cdot \text{abs}(corr)$
  'fisher' $\sqrt{n - 3} \cdot \frac{1}{2} \cdot \log\left(\frac{1 + corr}{1 - corr}\right)$
  'student' $\sqrt{n - 2} \cdot \text{abs}(corr) / \sqrt{1 - corr^2}$
  '2nd.order' $\sqrt{n} \cdot \text{mean}(Y) / \text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j))$
method choice between 'Bonferroni', 'Sidak', 'BootRW', 'MaxTinfty'
Nboot number of iterations for Monte-Carlo of bootstrap quantile evaluation
stepdown logical, if TRUE a stepdown procedure is applied
vect if TRUE returns a vector of adjusted p-values, corresponding to \text{vectorize}(\text{cor}(\text{data}));
  if FALSE, returns an array containing the adjusted p-values for each entry of the
correlation matrix
logical if TRUE, returns either a vector or a matrix where each element is equal to
  TRUE if the corresponding null hypothesis is rejected, and to FALSE if it is
  not rejected if stepdown=TRUE and logical=FALSE, returns a list of successive
  p-values.
arr.ind if TRUE, returns the indexes of the significant correlations, with respect to
  level alpha

Value

Returns either

- the adjusted p-values, as a vector or a matrix, depending on vect
- logicals indicating if the corresponding correlation is significant if logical=TRUE, as a vector
  or a matrix depending on vect,
- an array containing indexes $\{(i, j), i < j\}$ for which correlation between variables $i$ and $j$ is
  significant, if arr.ind=TRUE.

References

See Also

ApplyFwerCor_SD, ApplyFdrCor
BonferroniCor, SidakCor, BootRWCor, maxTinftyCor
BonferroniCor_SD, SidakCor_SD, BootRWCor_SD, maxTinftyCor_SD

Examples

```r
n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
data <- MASS::mvrnorm(n,rep(0,p),corr_theo)
# adjusted p-values
(res <- ApplyFwerCor(data,stat_test="empirical",method="Bonferroni",stepdown=FALSE))
# significant correlations, level alpha:
alpha <- 0.05
whichCor(res<alpha)
```

ApplyFwerCor_oracle

 Applies an oracle version of MaxTinfty procedure described in Drton & Perlman (2007) for correlation testing.

Description

Applies oracle MaxTinfty procedure described in Drton & Perlman (2007) which controls asymptotically the FWER for tests on a correlation matrix. It needs the true correlation matrix.

Usage

```r
ApplyFwerCor_oracle(
  data,
  corr_theo,
  alpha = c(),
  stat_test = "empirical",
  method = "MaxTinfty",
  Nboot = 1000,
  stepdown = TRUE,
  vect = FALSE,
  logical = stepdown,
  arr.ind = FALSE
)
```
Arguments

- **data**: matrix of observations
- **corr_theo**: true matrix of correlations
- **alpha**: level of multiple testing (used if logical=TRUE)
- **stat_test**: 'empirical' \( \sqrt{n} \ast \text{abs}(corr) \)
  - 'fisher' \( \sqrt{n-3} \ast 1/2 \ast \log((1 + corr)/(1 - corr)) \)
  - 'student' \( \sqrt{n-2} \ast \text{abs}(corr)/\sqrt(1 - corr^2) \)
  - '2nd.order' \( \sqrt{n} \ast \text{mean}(Y)/\text{sd}(Y) \) with \( Y = (X_i-\text{mean}(X_i))(X_j-\text{mean}(X_j)) \)
- **method**: only 'MaxTinfty' implemented
- **Nboot**: number of iterations for Monte-Carlo of bootstrap quantile evaluation
- **stepdown**: logical, if TRUE a stepdown procedure is applied
- **vect**: if TRUE returns a vector of adjusted p-values, corresponding to \( \text{vectorize(cor(data))} \); if FALSE, returns an array containing the adjusted p-values for each entry of the correlation matrix
- **logical**: if TRUE, returns either a vector or a matrix where each element is equal to TRUE if the corresponding null hypothesis is rejected, and to FALSE if it is not rejected if stepdown=TRUE and logical=FALSE, returns a list of successive p-values.
- **arr.ind**: if TRUE, returns the indexes of the significant correlations, with respect to level alpha

Value

Returns either

- the adjusted p-values, as a vector or a matrix, depending on vect (unavailable with stepdown)
- logicals indicating if the corresponding correlation is significant if logical=TRUE, as a vector or a matrix depending on vect,
- an array containing indexes \( \{(i, j), i < j \} \) for which correlation between variables \( i \) and \( j \) is significant, if arr.ind=TRUE.

Oracle estimation of the quantile is used, based on the true correlation matrix

References


See Also

ApplyFwerCor
maxTinftyCor, maxTinftyCor_SD
Examples

```r	n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
data <- MASS::mvrnorm(n,rep(0,p),corr_theo)
# adjusted p-values:
(res <- ApplyFwerCor_oracle(data,corr_theo,stat_test="empirical",Nboot=1000,stepdown=FALSE))
# significant correlations, level alpha:
alpha <- 0.05
whichCor(res<alpha)
```

BHBootCor

Benjamini & Hochberg (1995)'s procedure for correlation testing with bootstrap evaluation of p-values.

Description

Benjamini & Hochberg (1995)'s procedure on the correlation matrix entries with bootstrap evaluation of p-values (no theoretical proof of control).

Usage

```r
BHBootCor(
  data, 
  alpha = 0.05, 
  stat_test = "2nd.order", 
  Nboot = 100, 
  vect = FALSE, 
  arr.ind = FALSE
)
```

Arguments

data: matrix of observations
alpha: level of multiple testing
stat_test: ‘empirical’ $\sqrt{n} \cdot \text{abs}(corr)$
  ‘fisher’ $\sqrt{n - 3} \cdot 1/2 \cdot \log((1 + corr)/(1 - corr))$
  ‘student’ $\sqrt{n - 2} \cdot \text{abs}(corr)/\sqrt{1 - \text{corr}^2}$
  ‘2nd.order’ $\sqrt{n} \cdot \text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j))$
Nboot: number of iterations for bootstrap quantile evaluation
vect: if TRUE, returns a vector of TRUE/FALSE values, corresponding to `vectorize(cor(data))`;
  if FALSE, returns an array containing TRUE/FALSE values for each entry of the correlation matrix
arr.ind: if TRUE, returns the indexes of the significant correlations, with respect to level alpha
Value

Returns

- a vector or a matrix of logicals, equal to TRUE if the corresponding element of the statistic vector is rejected, if arr.ind=FALSE,
- an array containing indexes \{(i, j), \ i < j\} for which correlation between variables \(i\) and \(j\) is significant, if arr.ind=TRUE.

References


See Also

ApplyFdrCor, BHCor

Examples

```r
n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
data <- MASS::mvrnorm(n,rep(0,p),corr_theo)
alpha <- 0.05
# significant correlations:
BHBootCor(data,alpha,stat_test='empirical',arr.ind=TRUE)
```

<table>
<thead>
<tr>
<th>BHCor</th>
<th>Benjamini &amp; Hochberg (1995)'s procedure for correlation testing.</th>
</tr>
</thead>
</table>

Description

Benjamini & Hochberg (1995)’s procedure on the correlation matrix entries (no theoretical proof of control).

Usage

```r
BHCor(
    data, alpha = 0.05, stat_test = "2nd.order", vect = FALSE, arr.ind = FALSE
)
```
Arguments

data matrix of observations
alpha level of multiple testing
stat_test 'empirical' $\sqrt{n} \times \text{abs}(corr)$
 'fisher' $\sqrt{n - \frac{3}{2}} \times \text{log}((1 + \text{corr})/(1 - \text{corr}))$
 'student' $\sqrt{n - 2} \times \text{abs}(corr)/\sqrt{(1 - \text{corr}^2)}$
 '2nd.order' $\sqrt{n} \times \text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j))$

vect if TRUE returns a vector of TRUE/FALSE values, corresponding to vectorize(cor(data)) if FALSE, returns an array containing TRUE/FALSE values for each entry of the correlation matrix
arr.ind if TRUE, returns the indexes of the significant correlations, with respect to level alpha

Value

Returns

• logicals, equal to TRUE if the corresponding element of the statistic vector is rejected, as a vector or a matrix depending of the value of vect,

• an array containing indexes $\{(i, j), i < j\}$ for which correlation between variables $i$ and $j$ is significant, if arr.ind=TRUE.

References


See Also

ApplyFdrCor, BHBootCor

Examples

```r
n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
data <- MASS::mvrnorm(n,rep(0,p),corr_theo)
alpha <- 0.05
# significant correlations:
BHCor(data,alpha,stat_test='empirical',arr.ind=TRUE)
```
### BonferroniCor

*Bonferroni multiple testing procedure for correlations.*

---

#### Description

Bonferroni multiple testing procedure for correlations.

#### Usage

```r
BonferroniCor(
  data,  # matrix of observations
  alpha = 0.05,  # level of multiple testing (used if logical=TRUE)
  stat_test = "empirical",  # 'empirical' $\sqrt{n} \cdot \text{abs}(\text{corr})$
    # 'fisher' $\sqrt{n - 3} \cdot 1/2 \cdot \log((1 + \text{corr})/(1 - \text{corr}))$
    # 'student' $\sqrt{n - 2} \cdot \text{abs}(\text{corr})/\sqrt{(1 - \text{corr}^2)}$
    # '2nd.order' $\sqrt{n} \cdot \text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j))$
  vect = FALSE,  # if TRUE returns a vector of adjusted p-values, corresponding to vectorize(cor(data));
  logical = FALSE,  # if FALSE, returns an array containing the adjusted p-values for each entry of the correlation matrix
  arr.ind = FALSE
)
```

#### Arguments

- **data**: matrix of observations
- **alpha**: level of multiple testing (used if logical=TRUE)
- **stat_test**: `'empirical' $\sqrt{n} \cdot \text{abs}(\text{corr})$
  
  `'fisher' $\sqrt{n - 3} \cdot 1/2 \cdot \log((1 + \text{corr})/(1 - \text{corr}))$
  
  `'student' $\sqrt{n - 2} \cdot \text{abs}(\text{corr})/\sqrt{(1 - \text{corr}^2)}$
  
  `'2nd.order' $\sqrt{n} \cdot \text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j))$
- **vect**: if TRUE returns a vector of adjusted p-values, corresponding to vectorize(cor(data));
- **logical**: if TRUE, returns either a vector or a matrix where each element is equal to TRUE if the corresponding null hypothesis is rejected, and to FALSE if it is not rejected
- **arr.ind**: if TRUE, returns the indexes of the significant correlations, with respect to level alpha

#### Value

Returns

- the adjusted p-values, as a vector or a matrix depending of the value of vect,
- an array containing indexes $\{(i, j), i < j\}$ for which correlation between variables $i$ and $j$ is significant, if arr.ind=TRUE.
References


See Also

ApplyFwerCor, BonferroniCor_SD

Examples

\begin{verbatim}
  n <- 100
  p <- 10
  corr_theo <- diag(1,p)
  corr_theo[1,3] <- 0.5
  corr_theo[3,1] <- 0.5
  corr_theo <- diag(1,p)
  data <- MASS::mvrnorm(n,rep(0,p),corr_theo)
  # adjusted p-values
  res <- BonferroniCor(data,stat_test="empirical")
  round(res,2)
  # significant correlations with level alpha:
  alpha <- 0.05
  whichCor(res<alpha)
  # directly
  BonferroniCor(data,alpha,stat_test="empirical",arr.ind=TRUE)
\end{verbatim}
BonferroniCor_SD

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>data</td>
<td>matrix of observations</td>
</tr>
<tr>
<td>alpha</td>
<td>level of multiple testing</td>
</tr>
<tr>
<td>stat_test</td>
<td>4 test statistics are available:</td>
</tr>
<tr>
<td></td>
<td>'empirical' ( \sqrt{n} \times \text{abs}(\text{corr}) )</td>
</tr>
<tr>
<td></td>
<td>'fisher' ( \sqrt{n-3} \times \frac{1}{2} \times \log\left(\frac{1+\text{corr}}{1-\text{corr}}\right) )</td>
</tr>
<tr>
<td></td>
<td>'student' ( \sqrt{n-2} \times \frac{\text{abs}(\text{corr})}{\sqrt{1-\text{corr}^2}} )</td>
</tr>
<tr>
<td></td>
<td>'2nd.order' ( \sqrt{\text{n}} \times \text{mean}(Y) / \text{sd}(Y) ) with ( Y = (X_i-\text{mean}(X_i))(X_j-\text{mean}(X_j)) )</td>
</tr>
<tr>
<td>vect</td>
<td>if TRUE returns a vector of TRUE/FALSE values, corresponding to ( \text{vectorize}(\text{cor}(\text{data})) ); if FALSE, returns an array containing TRUE/FALSE values for each entry of the correlation matrix</td>
</tr>
<tr>
<td>logical</td>
<td>if TRUE, returns either a vector or a matrix where each element is equal to TRUE if the corresponding null hypothesis is rejected, and to FALSE if it is not rejected; if FALSE, returns a list of successive p-values: element ([i+1]) of the list giving the p-values evaluated on the non-rejected hypothesis at step ([i]); p-values are either as a vector or a list depending on vect</td>
</tr>
<tr>
<td>arr.ind</td>
<td>if TRUE, returns the indexes of the significant correlations, with respect to level alpha</td>
</tr>
</tbody>
</table>

Value

Returns

- logicals, equal to TRUE if the corresponding element of the statistic vector is rejected, as a vector or a matrix depending of the value of vect,
- an array containing indexes \( \{(i, j), i < j\} \) for which correlation between variables \( i \) and \( j \) is significant, if \( \text{arr}\_\text{ind}=\text{TRUE} \).

References


See Also

ApplyFwerCor, BonferroniCor

Examples

```r
n <- 100
p <- 10
corr_theo <- diag(1, p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
```
data <- MASS::mvrnorm(n, rep(0, p), corr_theo)
alpha <- 0.05

# significant correlations:
BonferroniCor_SD(data, alpha, stat_test = 'empirical', arr.ind = TRUE)

# successive p-values
res <- BonferroniCor_SD(data, alpha, stat_test = 'empirical', logical = FALSE)
lapply(res, FUN = function(x) (round(x, 2)))

# successive rejections
lapply(res, FUN = function(x) (whichCor(x < alpha)))

---

**BootRWCor**

Bootstrap multiple testing method of Romano & Wolf (2005) for correlations.

**Description**

Multiple testing method based on the evaluation of quantile by bootstrap in the initial dataset (Romano & Wolf (2005)).

**Usage**

BootRWCor(
  data,
  alpha = 0.05,
  stat_test = "empirical",
  Nboot = 1000,
  vect = FALSE,
  logical = FALSE,
  arr.ind = FALSE
)

**Arguments**

- **data**
  - matrix of observations
- **alpha**
  - level of multiple testing (used if logical=TRUE)
- **stat_test**
  - 'empirical' \( \sqrt{n} \times \text{abs}(\text{corr}) \)
  - 'fisher' \( \sqrt{n - 2} \times \text{abs}(\text{corr}) / \sqrt{(1 - \text{corr}^2)} \)
  - 'student' \( \sqrt{n - 2} \times \text{abs}(\text{corr}) / \sqrt{(1 - \text{corr}^2)} \)
  - '2nd.order' \( \sqrt{n} \times \text{mean}(Y) / \text{sd}(Y) \) with \( Y = (X_i - \text{mean}(X_i)) \times (X_j - \text{mean}(X_j)) \)
- **Nboot**
  - number of iterations for Monte-Carlo quantile evaluation
- **vect**
  - if TRUE returns a vector of adjusted p-values, corresponding to \( \text{vectorize}(\text{cor}(\text{data})) \);
  - if FALSE, returns an array containing the adjusted p-values for each entry of the correlation matrix
- **logical**
  - if TRUE, returns either a vector or a matrix where each element is equal to
  - TRUE if the corresponding null hypothesis is rejected, and to FALSE if it is not rejected
- **arr.ind**
  - if TRUE, returns the indexes of the significant correlations, with respect to level alpha
Value

Returns

- the adjusted p-values, as a vector or a matrix depending of the value of vect,
- an array containing indexes $\{(i, j), i < j\}$ for which correlation between variables $i$ and $j$ is significant, if arr.ind=TRUE.

References


See Also

ApplyFwerCor, BootRWCor_SD

Examples

```r
n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
data <- MASS::mvrnorm(n,rep(0,p),corr_theo)
# adjusted p-values
res <- BootRWCor(data,stat_test='empirical',Nboot=1000)
round(res,2)
# significant correlations with level alpha:
alpha <- 0.05
whichCor(res<alpha)
# directly
BootRWCor(data,alpha,stat_test='empirical',Nboot=1000,arr.ind=TRUE)
```

BootRWCor_SD

Bootstrap multiple testing method of Romano & Wolf (2005) for correlations, with stepdown procedure.

Description

Multiple testing method based on the evaluation of quantile by bootstrap in the initial dataset (Romano & Wolf (2005)), with stepdown procedure.
Usage

BootRWCor_SD(
  data,
  alpha = 0.05,
  stat_test = "empirical",
  Nboot = 1000,
  vect = FALSE,
  logical = TRUE,
  arr.ind = FALSE
)

Arguments

data matrix of observations
alpha level of multiple testing
stat_test 4 test statistics are available:
  'empirical' $\sqrt{n} \cdot \text{abs}(corr)$
  'fisher' $\sqrt{n - 3} \cdot 1/2 \cdot \log((1 + corr)/(1 - corr))$
  'student' $\sqrt{n - 2} \cdot \text{abs}(corr)/\sqrt{(1 - corr^2)}$
  '2nd.order' $\sqrt{n} \cdot \text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j))$
Nboot number of iterations for Bootstrap quantile evaluation
vect if TRUE returns a vector of TRUE/FALSE values, corresponding to vectorize(cor(data));
if FALSE, returns an array containing TRUE/FALSE values for each entry of the
correlation matrix
logical if TRUE, returns either a vector or a matrix where each element is equal to
TRUE if the corresponding null hypothesis is rejected, and to FALSE if it is not
rejected if FALSE, returns a list of successive p-values : element [[i+1]] of the
list giving the p-values evaluated on the non-rejected hypothesis at step [[i]];
p-values are either as a vector or a list depending on vect
arr.ind if TRUE, returns the indexes of the significant correlations, with respect to level
alpha

Value

Returns

- logicals, equal to TRUE if the corresponding element of the statistic vector is rejected, as a
  vector or a matrix depending of the value of vect,
- an array containing indexes \{\((i, j), i < j\}\} for which correlation between variables \(i\) and \(j\) is
  significant, if arr.ind=TRUE.

References

Roux, M. (2018). Graph inference by multiple testing with application to Neuroimaging, Ph.D.,
covD2nd

Returns the theoretical covariance of empirical correlations.

Description

Returns the theoretical covariance of empirical correlations.

Usage

covD2nd(r)

Arguments

r a correlation matrix

Value

Returns the theoretical covariance of 2nd order statistics, $\sqrt{n} \cdot \text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j))$. 

See Also

covDcor
Examples

```r
p <- 10
corr_theo <- diag(1, p)
corr_theo[2:p,] <- 0.3
corr_theo[,2:p] <- 0.3
covD2nd(corr_theo)
```

**Description**

Returns the theoretical covariance of empirical correlations.

**Usage**

```r
covDcor(r)
```

**Arguments**

- `r`  a correlation matrix

**Value**

Returns the theoretical covariance of empirical correlations.

**References**


**See Also**

covDcorNorm

**Examples**

```r
p <- 10
corr_theo <- diag(1, p)
corr_theo[2:p,] <- 0.3
corr_theo[,2:p] <- 0.3
covDcor(corr_theo)
```
covDcorNorm

Returns the theoretical covariance of test statistics for correlation testing.

Description

Returns the theoretical covariance of test statistics for correlation testing.

Usage

covDcorNorm(cor_mat, stat_test = "empirical")

Arguments

cor_mat A correlation matrix

stat_test ‘empirical’ $\sqrt{n} \cdot \text{abs}(corr)$

‘fisher’ $\sqrt{n-3} \cdot 1/2 \cdot \log((1 + corr)/(1 - corr))$

‘student’ $\sqrt{n-2} \cdot \text{abs}(corr)/\sqrt{1 - corr^2}$

‘2nd.order’ $\sqrt{n}\cdot\text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i-\text{mean}(X_i))(X_j-\text{mean}(X_j))$

Value

Returns the theoretical covariance of the test statistics.

See Also

covDcor, covD2nd, eval_stat

Examples

p <- 10
corr_theo <- diag(1,p)
corr_theo[2:p,] <- 0.3
corr_theo[,] <- 0.3
covDcorNorm(corr_theo, stat_test='student')

eval_stat

Evaluates the test statistics for tests on correlation matrix entries.

Description

Evaluates the test statistics for tests on correlation matrix entries.

Usage

eval_stat(data, type = "empirical")
Arguments

- **data**: matrix of observations
- **type**: 'empirical' $\sqrt{n} \cdot \text{abs}(\text{corr})$
- **fisher**: $\sqrt{n - 3} \cdot \frac{1}{2} \cdot \log((1 + \text{corr})/(1 - \text{corr}))$
- **student**: $\sqrt{n - 2} \cdot \text{abs}(\text{corr})/\sqrt{(1 - \text{corr}^2)}$
- **2nd.order**: $\sqrt{n} \cdot \text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j))$

Value

Returns the test statistics for correlation testing.

Examples

```r
n <- 100
p <- 10
corr_theo <- diag(1, p)
data <- MASS::mvrnorm(n, rep(0, p), corr_theo)
stat <- eval_stat(data, 'fisher')
```

Description

Bootstrap procedure LCT-B proposed by Cai & Liu (2016) for correlation testing.

Usage

```r
LCTboot(
data,
alpha = 0.05,
stat_test = "2nd.order",
Nboot = 100,
vect = FALSE,
arr.ind = FALSE
)
```

Arguments

- **data**: matrix of observations
- **alpha**: level of multiple testing
- **stat_test**: 'empirical' $\sqrt{n} \cdot \text{abs}(\text{corr})$
- **fisher**: $\sqrt{n - 3} \cdot \frac{1}{2} \cdot \log((1 + \text{corr})/(1 - \text{corr}))$
- **student**: $\sqrt{n - 2} \cdot \text{abs}(\text{corr})/\sqrt{(1 - \text{corr}^2)}$
- **2nd.order**: $\sqrt{n} \cdot \text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j))$
**Nboot**

number of iterations for bootstrap quantile evaluation

**vect**

if TRUE returns a vector of TRUE/FALSE values, corresponding to `vectorize(cor(data))`; if FALSE, returns an array containing TRUE/FALSE values for each entry of the correlation matrix

**arr.ind**

if TRUE, returns the indexes of the significant correlations, with respect to level alpha

**Value**

Returns

- logicals, equal to TRUE if the corresponding element of the statistic vector is rejected, as a vector or a matrix depending of the value of vect,
- an array containing indexes \{ \( (i, j), \ i < j \) \} for which correlation between variables \( i \) and \( j \) is significant, if arr.ind=TRUE.

**References**


**See Also**

ApplyFdrCor, LCTNorm

**Examples**

```r
n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
data <- MASS::mvrnorm(n,rep(0,p),corr_theo)
alpha <- 0.05
# significant correlations:
LCTboot(data, alpha, stat_test='empirical', Nboot=100, arr.ind=TRUE)
```

**Description**

Procedure LCT-N proposed by Cai & Liu (2016) for correlation testing.
Usage

LCTnorm(
  data,
  alpha = 0.05,
  stat_test = "2nd.order",
  vect = FALSE,
  arr.ind = FALSE
)

Arguments

data  matrix of observations
alpha  level of multiple testing
stat_test  'empirical' $\sqrt{n} \times \text{abs}(\text{corr})$
  'fisher' $\sqrt{n - 3} \times 1/2 \times \log((1 + \text{corr})/(1 - \text{corr}))$
  'student' $\sqrt{n - 2} \times \text{abs}(\text{corr})/\sqrt{1 - \text{corr}^2}$
  '2nd.order' $\sqrt{n} \times \text{mean}(\text{Y})/\text{sd}(\text{Y})$ with $\text{Y} = (\text{X}_i - \text{mean}(\text{X}_i))(\text{X}_j - \text{mean}(\text{X}_j))$
vect  if TRUE returns a vector of TRUE/FALSE values, corresponding to vectorize(cor(data));
  if FALSE, returns an array containing TRUE/FALSE values for each entry of the
  correlation matrix
arr.ind  if TRUE, returns the indexes of the significant correlations, with respect to level
  alpha

Value

Returns

- logicals, equal to TRUE if the corresponding element of the statistic vector is rejected, as a
  vector or a matrix depending of the value of vect,
- an array containing indexes $\{(i, j), i < j\}$ for which correlation between variables $i$ and $j$ is
  significant, if arr.ind=TRUE.

References

  Statistical Association, 111(513), 229-240.

See Also

ApplyFdrCor, LCTboot

Examples

n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
data <- MASS::mvrnorm(n, rep(0, p), corr_theo)
alpha <- 0.05
# significant correlations:
LCTnorm(data, alpha, stat_test='empirical', arr.ind=TRUE)

maxTinftyCor  
Multiple testing method of Drton & Perlman (2007) for correlations.

Description

Multiple testing method based on the evaluation of quantile by simulation of observations from the
asymptotic distribution (Drton & Perlman (2007)).

Usage

maxTinftyCor(
  data,
  alpha = 0.05,
  stat_test = "empirical",
  Nboot = 1000,
  OmegaChap = covDcorNorm(cor(data), stat_test),
  vect = FALSE,
  logical = FALSE,
  arr.ind = FALSE
)

Arguments

data  matrix of observations
alpha level of multiple testing (used if logical=TRUE)
stat_test
  'empirical' \( \sqrt{n} \cdot \text{abs}(\text{corr}) \)
  'fisher' \( \sqrt{n-3} \cdot \frac{1/2 \cdot \log((1 + \text{corr})/(1 - \text{corr}))}{1 - \text{corr}^2} \)
  'student' \( \sqrt{n-2} \cdot \frac{\text{abs}(\text{corr})}{\sqrt{(1 - \text{corr}^2)}} \)
  '2nd.order' \( \sqrt{n} \cdot \text{mean}(Y)/\text{sd}(Y) \) with \( Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j)) \)
Nboot number of iterations for Monte-Carlo quantile evaluation
OmegaChap  matrix of covariance of empirical correlations used for quantile evaluation; optional, useful for oracle estimation and step-down
vect if TRUE returns a vector of adjusted p-values, corresponding to \text{vectorize}(\text{cor(data)}); if FALSE, returns an array containing the adjusted p-values for each entry of the correlation matrix
logical if TRUE, returns either a vector or a matrix where each element is equal to TRUE if the corresponding null hypothesis is rejected, and to FALSE if it is not rejected
arr.ind if TRUE, returns the indexes of the significant correlations, with respect to level alpha
Value

Returns

- the adjusted p-values, as a vector or a matrix depending of the value of vect,
- an array containing indexes \{(i, j), i < j\} for which correlation between variables i and j is significant, if \(arr\ .ind=\text{TRUE}\).

References


See Also

ApplyFwerCor, maxTinftyCor_SD

Examples

```r
n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
data <- MASS::mvrnorm(n,rep(0,p),corr_theo)
# adjusted p-values
res <- maxTinftyCor(data,stat_test='empirical',Nboot=1000)
round(res,2)
# significant correlations with level alpha:
alpha <- 0.05
whichCor(res<alpha)
# directly
res <- maxTinftyCor(data,alpha,stat_test='empirical',Nboot=1000,arr.ind=TRUE)
```

maxTinftyCor_SD

Multiple testing method of Drton & Perlman (2007) for correlations, with stepdown procedure.

Description

Multiple testing method based on the evaluation of quantile by simulation of observations from the asymptotic distribution (Drton & Perlman (2007)), with stepdown procedure.
maxTinftyCor_SD

Usage

maxTinftyCor_SD(
  data,
  alpha = 0.05,
  stat_test = "empirical",
  Nboot = 1000,
  OmegaChap = covDcorNorm(cor(data), stat_test),
  vect = FALSE,
  logical = TRUE,
  arr.ind = FALSE
)

Arguments

data matrix of observations
alpha level of multiple testing
stat_test 4 test statistics are available:
  'empirical' $\sqrt{n} \times |corr|$
  'fisher' $\sqrt{n} - 3 \times 1/2 \times \log((1 + corr)/(1 - corr))$
  'student' $\sqrt{n - 2} \times |corr|/\sqrt{(1 - corr^2)}$
  '2nd.order' $\sqrt{n}\times mean(Y)/sd(Y)$ with $Y = (X_i - mean(X_i))(X_j - mean(X_j))$
Nboot number of iterations for Monte-Carlo quantile evaluation
OmegaChap matrix of covariance of test statistics; optional, useful for oracle estimation and step-down
vect if TRUE returns a vector of TRUE/FALSE values, corresponding to vectorize(cor(data)); if FALSE, returns an array containing TRUE/FALSE values for each entry of the correlation matrix
logical if TRUE, returns either a vector or a matrix where each element is equal to TRUE if the corresponding null hypothesis is rejected, and to FALSE if it is not rejected if FALSE, returns a list of successive p-values: element [[i+1]] of the list giving the p-values evaluated on the non-rejected hypothesis at step [[i]]: p-values are either as a vector or a list depending on vect
arr.ind if TRUE, returns the indexes of the significant correlations, with respect to level alpha

Value

Returns

- logicals, equal to TRUE if the corresponding element of the statistic vector is rejected, as a vector or a matrix depending of the value of vect,
- an array containing indexes \{(i, j), i < j\} for which correlation between variables i and j is significant, if arr.ind=TRUE.
SidakCor

Sidak multiple testing procedure for correlations.

Description

Sidak multiple testing procedure for correlations.

Usage

SidakCor(
  data,
  alpha = 0.05,
  stat_test = "empirical",
  vect = FALSE,
  logical = FALSE,
  arr.ind = FALSE
)
Arguments

data matrix of observations
alpha level of multiple testing (used if logical=TRUE)
stat_test 'empirical' $\sqrt{n} \times \text{abs}(\text{corr})$
  'fisher' $\sqrt{n-3} \times 1/2 \times \log((1 + \text{corr})/(1 - \text{corr}))$
  'student' $\sqrt{n-2} \times \text{abs}(\text{corr})/\sqrt{1 - \text{corr}^2}$
  '2nd.order' $\sqrt{n} \times \text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j))$
vect if TRUE returns a vector of adjusted p-values, corresponding to \text{vectorize}(\text{cor}(\text{data}))
if FALSE, returns an array containing the adjusted p-values for each entry of the correlation matrix
logical if TRUE, returns either a vector or a matrix where each element is equal to TRUE if the corresponding null hypothesis is rejected, and to FALSE if it is not rejected
arr.ind if TRUE, returns the indexes of the significant correlations, with respect to level alpha

Value

Returns

- the adjusted p-values, as a vector or a matrix depending of the value of vect,
- an array containing indexes \{(i, j), i < j\} for which correlation between variables i and j is significant, if arr.ind=TRUE.

References


See Also

ApplyFwerCor, SidakCor_SD

Examples

```r
n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
data <- MASS::mvrnorm(n,rep(0,p),corr_theo)
# adjusted p-values
res <- SidakCor(data,stat_test='empirical')
round(res,2)
```
# significant correlations with level alpha:
alpha <- 0.05
whichCor(res<alpha)
# directly
SidakCor(data,alpha,stat_test='empirical',arr.ind=TRUE)

---

SidakCor_SD

Sidak multiple testing method for correlations with stepdown procedure.

## Description

Sidak multiple testing method for correlations with stepdown procedure.

## Usage

SidakCor_SD(
  data,
  alpha = 0.05,
  stat_test = "empirical",
  vect = FALSE,
  logical = TRUE,
  arr.ind = FALSE
)

## Arguments

- **data**: matrix of observations
- **alpha**: level of multiple testing
- **stat_test**: 4 test statistics are available:
  - 'empirical' \( \sqrt{n} \cdot \text{abs}(corr) \)
  - 'fisher' \( \sqrt{n-3+1/2 \cdot \log((1+corr)/(1-corr))} \)
  - 'student' \( \sqrt{n-2 \cdot \text{abs}(corr)}/\sqrt{1-corr^2} \)
  - '2nd.order' \( \sqrt{n} \cdot \text{mean}(Y)/\text{sd}(Y) \) with \( Y = (X_i-\text{mean}(X_i))(X_j-\text{mean}(X_j)) \)
- **vect**: if TRUE returns a vector of TRUE/FALSE values, corresponding to \text{vectorize}(\text{cor}(data)); if FALSE, returns an array containing TRUE/FALSE values for each entry of the correlation matrix
- **logical**: if TRUE, returns either a vector or a matrix where each element is equal to TRUE if the corresponding null hypothesis is rejected, and to FALSE if it is not rejected; if FALSE, returns a list of successive p-values: element \([i+1]\) of the list giving the p-values evaluated on the non-rejected hypothesis at step \([i]\); p-values are either as a vector or a list depending on vect
- **arr.ind**: if TRUE, returns the indexes of the significant correlations, with respect to level alpha
SimuFdr

Value

Returns

- logicals, equal to TRUE if the corresponding element of the statistic vector is rejected, as a vector or a matrix depending of the value of vect,
- an array containing indexes \{(i, j), i < j\} for which correlation between variables \(i\) and \(j\) is significant, if arr.ind=TRUE.

References


See Also

ApplyFwerCor, SidakCor

Examples

```r
n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
data <- MASS::mvrnorm(n,rep(0,p),corr_theo)
alpha <- 0.05
# significant correlations:
SidakCor_SD(data, alpha, stat_test='empirical', arr.ind=TRUE)
# successive p-values
res <- SidakCor_SD(data, stat_test='empirical', logical=FALSE)
lapply(res,FUN=function(x){round(x,2)})
# successive rejections
lapply(res,FUN=function(x){whichCor(x<alpha)})
```

SimuFdr

Simulates Gaussian data with a given correlation matrix and applies a FDR controlling procedure on the correlations.

Description

Simulates Gaussian data with a given correlation matrix and applies a FDR controlling procedure on the correlations.
Usage

```r
SimuFdr(
    corr_theo,
    n = 100,
    Nsimu = 1,
    alpha = 0.05,
    stat_test = "empirical",
    method = "LCTnorm",
    Nboot = 1000,
    seed = NULL
)
```

Arguments

- `corr_theo`: the correlation matrix of Gaussian data simulated
- `n`: sample size
- `Nsimu`: number of simulations
- `alpha`: level of multiple testing
- `stat_test`: choice between 'empirical', $\sqrt{n} \cdot \text{abs}(corr)$, 'fisher', $\sqrt{n - 3} \cdot 1/2 \cdot \log((1 + corr)/(1 - corr))$, 'student', $\sqrt{n - 2} \cdot \text{abs}(corr)/\sqrt{1 - corr^2}$, 'gaussian', $\sqrt{n} \cdot \text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i)) (X_j - \text{mean}(X_j))$
- `Nboot`: number of iterations for Monte-Carlo of bootstrap quantile evaluation
- `seed`: seed for the Gaussian simulations

Value

Returns a line vector containing estimated values for fwer, fdr, sensitivity, specificity and accuracy.

References


See Also

- `ApplyFdrCor`, `SimuFwer`
SimuFwer

Examples

```r
Nsimu <- 1000
n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
alpha <- 0.05
SimuFdr(corr_theo,n,Nsimu,alpha,stat_test='empirical',method='LCTnorm')
```

SimuFwer

Simulates Gaussian data with a given correlation matrix and applies a FWER controlling procedure on the correlations.

Description

Simulates Gaussian data with a given correlation matrix and applies a FWER controlling procedure on the correlations.

Usage

```r
SimuFwer(
  corr_theo,
  n = 100,
  Nsimu = 1,
  alpha = 0.05,
  stat_test = "empirical",
  method = "Sidak",
  Nboot = 1000,
  stepdown = TRUE,
  seed = NULL
)
```

Arguments

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>corr_theo</td>
<td>the correlation matrix of Gaussian data simulated</td>
</tr>
<tr>
<td>n</td>
<td>sample size</td>
</tr>
<tr>
<td>Nsimu</td>
<td>number of simulations</td>
</tr>
<tr>
<td>alpha</td>
<td>level of multiple testing</td>
</tr>
<tr>
<td>stat_test</td>
<td>choice between 'empirical', 'fisher', 'student', 'gaussian'</td>
</tr>
<tr>
<td>method</td>
<td>choice between 'Bonferroni', 'Sidak', 'BootRW', 'MaxTinfty'</td>
</tr>
<tr>
<td>Nboot</td>
<td>number of iterations for Monte-Carlo of bootstrap quantile evaluation</td>
</tr>
<tr>
<td>stepdown</td>
<td>logical, if TRUE a stepdown procedure is applied</td>
</tr>
<tr>
<td>seed</td>
<td>seed for the Gaussian simulations</td>
</tr>
</tbody>
</table>
Value

Returns a line vector containing estimated values for fwer, fdr, sensitivity, specificity and accuracy.

References


See Also

ApplyFwerCor, SimuFwer_oracle, SimuFdr

Examples

Nsimu <- 1000
n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
alpha <- 0.05
SimuFwer(corr_theo,n,Nsimu,alpha,stat_test='empirical',method='Bonferroni',stepdown=FALSE)
alpha = 0.05,
stat_test = "empirical",
method = "MaxTinfty",
Nboot = 1000,
stepdown = TRUE,
seed = NULL
)

Arguments

corr_theo  the correlation matrix of Gaussian data simulated
n           sample size
Nsimu       number of simulations
alpha       level of multiple testing
stat_test   'empirical' $\sqrt{n} \cdot \text{abs}(corr)$
            'fisher' $\sqrt{n - 3 \cdot 1/2 \cdot \log((1 + corr)/(1 - corr))}$
            'student' $\sqrt{n - 2 \cdot \text{abs}(corr)}/\sqrt{(1 - corr^2)}$
            'gaussian' $\sqrt{n} \cdot \text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j))$
method      only 'MaxTinfty' available
Nboot       number of iterations for Monte-Carlo of bootstrap quantile evaluation
stepdown    logical, if TRUE a stepdown procedure is applied
seed        seed for the Gaussian simulations

Value

Returns a line vector containing estimated values for fwer, fdr, sensitivity, specificity and accuracy.

References


See Also

ApplyFwerCor_Oracle, SimuFwer

Examples

Nsimu <- 1000
n <- 50
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
alpha <- 0.05
SimuFwer_oracle(corr_theo,n,Nsimu,alpha,stat_test='empirical',stepdown=FALSE,Nboot=100)
Uncorrected testing procedure for correlations.

Description

Uncorrected testing procedure for correlations.

Usage

```r
UncorrectedCor(
  data,
  alpha = 0.05,
  stat_test = "empirical",
  vect = FALSE,
  logical = FALSE,
  arr.ind = FALSE
)
```

Arguments

data: matrix of observations
alpha: level of multiple testing (used if logical=TRUE)
stat_test: 'empirical' $\sqrt{n} \cdot \text{abs}(corr)$
  'fisher' $\sqrt{n - 3} \cdot 1/2 \cdot \log((1 + corr)/(1 - corr))$
  'student' $\sqrt{n - 2} \cdot \text{abs}(corr)/\sqrt{1 - corr^2}$
  '2nd.order' $\sqrt{n}\cdot\text{mean}(Y)/\text{sd}(Y)$ with $Y = (X_i - \text{mean}(X_i))(X_j - \text{mean}(X_j))$
vect: if TRUE returns a vector of adjusted p-values, corresponding to `vectorize(cor(data))`; if FALSE, returns an array containing the adjusted p-values for each entry of the correlation matrix
logical: if TRUE, returns either a vector or a matrix where each element is equal to TRUE if the corresponding null hypothesis is rejected, and to FALSE if it is not rejected
arr.ind: if TRUE, returns the indexes of the significant correlations, with respect to level alpha

Value

Returns

- the non-adjusted p-values, as a vector or a matrix depending of the value of vect,
- an array containing indexes \{\((i, j), i < j\)\} for which correlation between variables \(i\) and \(j\) is significant, if arr.ind=TRUE.
unvectorize

**Examples**

```r
n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
data <- MASS::mvrnorm(n,rep(0,p),corr_theo)
# p-values
res <- UncorrectedCor(data,stat_test="empirical")
round(res,2)
# significant correlations with level alpha:
alpha <- 0.05
whichCor(res<alpha)
# directly
UncorrectedCor(data,alpha,stat_test="empirical",arr.ind=TRUE)
```

---

**unvectorize**

*Returns an upper-triangle matrix, without the diagonal, containing the elements of a given vector.*

**Description**

Returns an upper-triangle matrix, without the diagonal, containing the elements of a given vector.

**Usage**

```r
unvectorize(vect)
```

**Arguments**

- `vect` A vector containing the upper triangle of a matrix, without the diagonal

**Value**

Returns an upper-triangle matrix where each entry is given by the vector containing the upper triangle of a matrix, without the diagonal.

**See Also**

- `vectorize`

**Examples**

```r
unvectorize(1:10)
```
vectorize

Returns a vector containing the upper triangle of a matrix, without the diagonal.

Description
Returns a vector containing the upper triangle of a matrix, without the diagonal.

Usage
vectorize(mat)

Arguments
mat a square matrix

Value
Returns a vector containing the upper triangle of a matrix, without the diagonal.

See Also
unvectorize

Examples
vectorize(matrix(1:9,3,3))

whichCor

Returns the indexes of an upper triangular matrix with logical entries.

Description
Returns the indexes of an upper triangular matrix with logical entries.

Usage
whichCor(mat)

Arguments
mat A matrix with logical entries in the upper triangular part

Value
Returns the indexes of the upper triangular part where the entries are TRUE
Examples

```r
n <- 100
p <- 10
corr_theo <- diag(1,p)
corr_theo[1,3] <- 0.5
corr_theo[3,1] <- 0.5
data <- MASS::mvrnorm(n, rep(0, p), corr_theo)
res <- ApplyFwerCor(data, stat_test='empirical', method='Bonferroni', stepdown=FALSE)
# significant correlations, level alpha:
alpha <- 0.05
whichCor(res<alpha)
```
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