Package ‘gMCP’

February 19, 2015

Type Package
Title Graph Based Multiple Comparison Procedures
Version 0.8-8
Maintainer Kornelius Rohmeyer <rohmeyer@small-projects.de>
Description This package provides functions and a graphical user interface for graphical described multiple test procedures.
Depends R (>= 3.0.0), rJava (>= 0.6-3), JavaGD, methods, xlsxjars (>= 0.6.1)
Imports MASS, PolynomF, multcomp (>= 1.1), mvtnorm, Matrix,
CommonJavaJars (>= 1.0.5), stats4
Suggests RUnit, Deducer, knitr, graph (>= 1.20), mutoss, boot, coin
VignetteBuilder knitr
SystemRequirements Java (>= 5.0)
License GPL (>= 2)
URL http://gsrmp.r-forge.r-project.org/
BugReports https://github.com/kornl/gMCP/issues
Author Kornelius Rohmeyer [aut, cre],
Florian Klinglmueller [aut]
NeedsCompilation yes
Repository CRAN
Date/Publication 2014-10-03 01:11:49

R topics documented:

  gMCP-package ....................................................... 2
  bdiagNA .............................................................. 4
  calcPower ............................................................ 5
  corMatWizard ........................................................ 7
  doInterim ........................................................... 8
  entangledMCP-class .................................................. 10
This package provides functions and graphical user interfaces for graphical described multiple comparison procedures.
The package gMCP helps with the following steps of performing a multiple test procedure:

1. Creating a object of `graphMCP` that represents a sequentially rejective multiple test procedure. This can be either done directly via the `new` function or converter functions like `matrix2graph` at the R command line or by using a graphical user interface started with function `graphGUI`.

2. Calling `gMCP` or `graphGUI`.

3. Exporting the results (optional with all sequential steps) as LaTeX or Word report.

**Note**

We use the following Java libraries:

- JRI under Lesser General Public License (LGPL) 2.1, [http://www.rforge.net/rJava/](http://www.rforge.net/rJava/), Copyright 2004-2007 Simon Urbanek
- iText 2.1.4 under LGPL, [http://itextpdf.com/](http://itextpdf.com/), Copyright by Bruno Lowagie
- SwingWorker under LGPL, [https://swingworker.dev.java.net/](https://swingworker.dev.java.net/), Copyright (c) 2005 Sun Microsystems
- JXLayer under BSD License, [https://jxlayer.dev.java.net/](https://jxlayer.dev.java.net/), Copyright 2006-2009, Alexander Potochkin
- JHLIR under BSD License, [http://jhlir.r-forge.r-project.org/](http://jhlir.r-forge.r-project.org/), Copyright (c) 2008-2014 by Bernd Bischl and Kornelius Rohmeyer

**Author(s)**

Kornelius Rohmeyer, R code for correlated tests and adaptive designs from Florian Klinglmueller.
Maintainer: Kornelius Rohmeyer <rohmeyer@small-projects.de>
References


Examples

g5 <- BonferroniHolm(5)
## Not run:
graphGUI("g5")
## End(Not run)
gMCP(g5, pvalues=c(0.1,0.2,0.4,0.4,0.4))

---

bdiagNA

Create a Block Diagonal Matrix with NA outside the diagonal

Description

Build a block diagonal matrix with NA values outside the diagonal given several building block matrices.

Usage

bdiagNA(...)

Arguments

... individual matrices or a list of matrices.

Details

This function is usefull to build the correlation matrices, when only partial knowledge of the correlation exists.

Value

A block diagonal matrix with NA values outside the diagonal.

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>
Calculate power values

Description

Given the distribution under the alternative (assumed to be multivariate normal), this function calculates the power to reject at least one hypothesis, the local power for the hypotheses as well as the expected number of rejections.

Usage

```r
calcpower(weights, alpha, G, mean = rep(0, nrow(corr.sim)),
corr.sim = diag(length(mean)), corr.test = NULL, nSim = 10000,
type = c("quasirandom", "pseudorandom"), f = list(), test, ...)
```

Arguments

- `weights`: Initial weight levels for the test procedure, see graphTest function.
- `alpha`: Overall alpha level of the procedure, see graphTest function. (For entangled graphs `alpha` should be a numeric vector of length equal to the number of graphs, each element specifying the partial alpha for the respective graph. The overall alpha level equals `sum(alpha)`.)
- `G`: Matrix determining the graph underlying the test procedure. Note that the diagonal need to contain only 0s, while the rows need to sum to 1. When multiple graphs should be used this needs to be a list containing the different graphs as elements.
- `mean`: Mean under the alternative
- `corr.sim`: Covariance matrix under the alternative.
- `corr.test`: Correlation matrix that should be used for the parametric test. If `corr.test=NULL` the Bonferroni based test procedure is used. Can contain NAs.
- `type`: What type of random numbers to use. `quasirandom` uses a randomized Lattice rule, and should be more efficient than `pseudorandom` that uses ordinary (pseudo) random numbers.
- `nSim`: Monte Carlo sample size. If `type = "quasirandom"` this number is rounded up to the next power of 2, e.g. 1000 is rounded up to 1024 = $2^{10}$ and at least 1024.

Examples

```r
bdiagNA(diag(3), matrix(1/2, nr=3, nc=3), diag(2))
```
calcPower

f List of user defined power functions (or just a single power function). If one is interested in the power to reject hypotheses 1 and 3 one could specify:
f=function(x) {x[1] & x[3]}.
If the power of rejecting hypotheses 1 and 2 is also of interest one would use a (optionally named) list:
f=list(power1and3=function(x) {x[1] & x[3]}, power1and2=function(x) {x[1] & x[2]}). If the list has no names, the functions will be referenced to as "func1", "func2", etc. in the output.

test In the parametric case there is more than one way to handle subgraphs with less than the full alpha. If the parameter test is missing, the tests are performed as described by Bretz et al. (2011), i.e. tests of intersection null hypotheses always exhaust the full alpha level even if the sum of weights is strictly smaller than one. If test="simple-parametric" the tests are performed as defined in Equation (3) of Bretz et al. (2011).

... For backwards compatibility. For example up to version 0.8-7 the parameters corr.model and corr.test were called sigma and cr.

Value
A list containg three elements

LocalPower A numeric giving the local powers for the hypotheses
ExpRejections The expected number of rejections
PowAtLstlst1 The power to reject at least one hypothesis

References

Examples

## reproduce example from Stat Med paper (Bretz et al. 2010, Table I)
## first only consider line 2 of Table I
## significance levels
weights <- c(1/2, 1/2, 0, 0)
## graph
G <- rbind(c(0, 0.5, 0.5, 0),
           c(0.5, 0, 0, 0.5),
           c(0, 1, 0, 0),
           c(1, 0, 0, 0))
## or equivalent:
G <- simpleSuccessiveII()
## alternative (mvn distribution)
corMat <- rbind(c(1, 0.5, 0.5, 0.5/2),
                c(0.5, 0.5/2, 0.5),
                c(0.5, 0.5/2, 1, 0.5),
                c(0.5, 0.5/2, 1, 0.5),
                c(0.5, 0.5, 0, 1),
                c(0.5, 0.5, 0.5, 1),
                c(0.5, 0.5, 0.5, 1),
                c(0.5, 0.5, 0.5, 1),
                c(0.5, 0.5, 0.5, 1),
                c(0.5, 0.5, 0.5, 1)
c(0.5/2,0.5,0.5,1))
theta <- c(3,0,0,0)
calcPower(weights, alpha=0.025, G, theta, corMat, nSim = 100000)

## now reproduce all 14 simulation scenarios
## different graphs
weights1 <- c(rep(1/2, 12), 1, 1)
weights2 <- c(rep(1/2, 12), 0, 0)
eps <- 0.01
gam1 <- c(rep(0.5, 10), 1-eps, 0, 0, 0)
gam2 <- gam1
## different multivariate normal alternatives
rho <- c(rep(0.5, 8), 0.99, rep(0.5,4))
theta1 <- c(0, 3, 3, 3, 2, 1, rep(3, 7), 0)
theta2 <- c(rep(0, 6), 3, 3, 3, 3, 0, 0, 0, 3)
theta3 <- c(0, 0, 3, 3, 3, 3, 0, 2, 2, 2, 3, 3, 3, 3)
theta4 <- c(0,0,0,3,3,0,2,2,0,0,0)

## function that calculates power values for one scenario
simfunc <- function(nSim, a1, a2, g1, g2, rh, t1, t2, t3, t4, Gr){
al <- c(a1, a2, 0, 0)
G <- rbind(c(0, g1, 1-g1, 0), c(g2, 0, 0, 1-g2), c(0, 1, 0, 0), c(1, 0, 0, 0))
corMat <- rbind(c(1, 0.5, rh, rh/2), c(0.5,1,rh/2,rh), c(rh,rh/2,1,0.5), c(rh/2,rh,0.5,1))
mean <- c(t1, t2, t3, t4)
calcPower(al, alpha=0.025, G, mean, corMat, nSim = nSim)
}

## calculate power for all 14 scenarios
outlist1 <- list()
for(i in 1:14){
 outlist1[[i]] <- simfunc(10000, weights1[i], weights2[i],
 gam1[i], gam2[i], rho[i], theta1[i], theta2[i], theta3[i], theta4[i])
}

## summarize data as in Stat Med paper Table I
atlst1 <- as.numeric(lapply(outlist1, function(x) x$PowAtlst1))
locpow <- do.call("cbind", lapply(outlist1, function(x) x$LocPow))
round(cbind(atlst1, locpow), 5)

---

**corMatWizard**

**Graphical User Interface for the creation of correlation matrices**

**Description**

Starts a graphical user interface for the correlation matrices.
Usage

corMatWizard(n = dim(matrix)[1], matrix = paste("diag(", n, ")"),
names = paste("H", 1:n, sep = ""), envir = globalenv())

Arguments

n 
Square root of the dimension of the $n \times n$-Matrix.

matrix 
Matrix of dimension $n \times n$ to start with.

names 
Row and column names.

envir 
Environment where the object matrix is located and/or it should be saved (default is the global environment).

Value

The function itself returns NULL. But with the dialog a symmetric matrix of dimension $n \times n$ can be created or edited that will be available in R under the specified variable name after saving.

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

Examples

```r
# Not run:
corMatWizard(5)
C <- cor(matrix(rnorm(100),10), matrix(rnorm(100),10))
corMatWizard(matrix="C")

# End(Not run)
```

doInterim

EXPERIMENTAL: Evaluate conditional errors at interim for a pre-planned graphical procedure

Description

Computes partial conditional errors (PCE) for a pre-planned graphical procedure given information fractions and first stage z-scores. - Implementation of adaptive procedures is still in an early stage and may change in the near future

Usage

doInterim(graph, z1, v, alpha = 0.025)
Arguments

- **graph**: A graph of class `graphMCP`.
- **z1**: A numeric vector giving first stage z-scores.
- **v**: A numeric vector giving the proportions of pre-planned measurements collected up to the interim analysis. Will be recycled of length different than the number of elementary hypotheses.
- **alpha**: A numeric specifying the maximal allowed type one error rate.

Details

For details see the given references.

Value

An object of class `gPADInterim`, more specifically a list with elements

- **A**: a matrix of PCEs for all elementary hypotheses in each intersection hypothesis
- **BJ**: a numeric vector giving sum of PCEs per intersection hypothesis
- **preplanned**: Pre planned test represented by an object of class `graphMCP`

Author(s)

Florian Klinglmueller <float@lefant.net>

References


Posch M, Maurer W, Bretz F (2010): Type I error rate control in adaptive designs for confirmatory clinical trials with treatment selection at interim Pharm Stat 10/2, 96-104

See Also

`graphMCP`, `secondStageTest`
Examples

```r
## Simple successive graph (Maurer et al. 2011)
## two treatments two hierarchically ordered endpoints
a <- .025
G <- simpleSuccessive()
## some z-scores:
p1=c(.1,..12,.21,16)
z1 <- qnorm(1-p1)
p2=c(.04,1,14,1)
z2 <- qnorm(1-p2)
v <- c(1/2,1/3,1/2,1/3)

intA <- doInterim(G,z1,v)
## select only the first treatment
fTest <- secondStageTest(intA,c(1,0,1,0))
```

Description

A entangledMCP object describes ... TODO

Slots

- `subgraphs`: A list of graphs of class graphMCP.
- `weights`: A numeric.
- `graphAttr`: A list for graph attributes like color, etc.

Methods

- `print` signature(object = "entangledMCP"): A method for printing the data of the entangled graph to the R console.
- `getMatrices` signature(object = "entangledMCP"): A method for getting the list of transition matrices of the entangled graph.
- `getWeights` signature(object = "entangledMCP"): A method for getting the matrix of weights of the entangled graph.
- `getRejected` signature(object = "entangledMCP"): A method for getting the information whether the hypotheses are marked in the graph as already rejected. If a second optional argument `node` is specified, only for these nodes the boolean vector will be returned.
- `getXCoordinates` signature(object = "entangledMCP"): A method for getting the x coordinates of the graph. If a second optional argument `node` is specified, only for these nodes the x coordinates will be returned. If x coordinates are not yet set, NULL is returned.
- `getYCoordinates` signature(object = "entangledMCP"): A method for getting the y coordinates of the graph. If a second optional argument `node` is specified, only for these nodes the x coordinates will be returned. If y coordinates are not yet set, NULL is returned.
exampleGraphs

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

See Also

graphMCP

Examples

```r

  g1 <- BonferroniHolm(2)
  g2 <- BonferroniHolm(2)

  graph <- new("entangledMCP", subgraphs=list(g1,g2), weights=c(0.5,0.5))

  getMatrices(graph)
  getWeights(graph)
```

Description

Functions that create different example graphs, e.g. graphs that represents a Bonferroni-Holm adjustment, parallel gatekeeping or special procedures from selected papers.

Usage

BonferroniHolm(n)
BretzEtAl2011()
BauerEtAl2001()
BretzEtAl2009a()
BretzEtAl2009b()
BretzEtAl2009c()
HommelEtAl2007()
HommelEtAl2007Simple()
parallelGatekeeping()
improvedParallelGatekeeping()
fallback(weights)
fixedSequence(n)
simpleSuccessiveI()
simpleSuccessiveII()
truncatedHolm(gamma)
generalSuccessive(weights = c(1/2, 1/2), gamma, delta)
HuqueAloshEtBhore2011()
HungEtWang2010(nu, tau, omega)
MaurerEtAl1995()
cycleGraph(nodes, weights)
improvedFallbackI(weights = rep(1/3, 3))
improvedFallbackII(weights = rep(1/3, 3))
FerberTimeDose2011(times, doses, w = "\nu")
Ferber2011(w)
Entangled1Maurer2012()
Entangled2Maurer2012()
WangTing2014(nu, tau)

Arguments

n Number of hypotheses.

nodes Character vector of node names.

weights Numeric vector of node weights.

times Number of time points.

doses Number of dose levels.

w Further variable weight(s) in graph.

gamma An optional number in [0,1] specifying the value for variable gamma.

delta An optional number in [0,1] specifying the value for variable delta.

nu An optional number in [0,1] specifying the value for variable nu.
tau An optional number in [0,1] specifying the value for variable tau.

omega An optional number in [0,1] specifying the value for variable omega.

Details

We are providing functions and not the resulting graphs directly because this way you have additional examples: You can look at the function body with `body` and see how the graph is built.

- `list("BonferroniHolm")` Returns a graph that represents a Bonferroni-Holm adjustment. The result is a complete graph, where all nodes have the same weights and each edge weight is \( \frac{1}{n-\tau} \).

- `list("BretzEtAl2011")` Graph in figure 2 from Bretz et al. See references (Bretz et al. 2011).

- `list("HommelEtAl2007")` Graph from Hommel et al. See references (Hommel et al. 2007).

- `list("parallelGatekeeping")` Graph for parallel gatekeeping. See references (Dmitrienko et al. 2003).

- `list("improvedParallelGatekeeping")` Graph for improved parallel gatekeeping. See references (Hommel et al. 2007).

- `list("HungEtWang2010")` Graph from Hung et Wang. See references (Hung et Wang 2010).

- `list("MaurerEtAl1995")` Graph from Maurer et al. See references (Maurer et al. 1995).

- `list("cycleGraph")` Cycle graph. The weight \( \text{weights}[i] \) specifies the edge weight from node \( i \) to node \( i + 1 \) for \( i = 1, \ldots, n - 1 \) and weight \( [n] \) from node \( n \) to node 1.

- `list("improvedFallbackI")` Graph for the improved Fallback Procedure by Wiens & Dmitrienko. See references (Wiens et Dmitrienko 2005).

- `list("improvedFallbackII")` Graph for the improved Fallback Procedure by Hommel & Bretz. See references (Hommel et Bretz 2008).

- `list("Ferber2011")` Graph from Ferber et al. See references (Ferber et al. 2011).

- `list("FerberTimeDose2011")` Graph from Ferber et al. See references (Ferber et al. 2011).

- `list("Entangled1Maurer2012")` Entangled graph from Maurer et al. TODO: Add references as soon as they are available.

Value

A graph of class `graphMCP` that represents a sequentially rejective multiple test procedure.

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

References


**Examples**

```r
g <- BonferroniHolm(5)
gMCP(g, pvalues=c(0.1, 0.2, 0.4, 0.4, 0.7))
HungEtWang2010()
HungEtWang2010(nu=1)
```

---

**extractPower**

*Calculate power values*

**Description**

Calculates local power values, expected number of rejections, the power to reject at least one hypothesis and the power to reject all hypotheses.

**Usage**

```r
extractPower(x, f = list())
```
**generateBounds**

**Arguments**

x  
A matrix containing the rejected hypothesis, as produces by the graphTest function.

f  
List of user defined power functions. If one is interested in the power to reject hypotheses 1 and 3 one could specify function(x) {x[1] && x[3]}

**Value**

A list containing at least the following four elements and an element for each element in the parameter f.

LocPower  
A numeric giving the local powers for the hypotheses

ExpNrRej  
The expected number of rejections

PowAtlst1  
The power to reject at least one hypothesis

RejectAll  
The power to reject all hypotheses

**Description**

compute rejection bounds for z-scores of each elementary hypotheses within each intersection hypotheses

**Usage**

generateBounds(g, w, cr, al = 0.05, hint = generateWeights(g, w),
upscale = FALSE)

**Arguments**

**g**  
graph defined as a matrix, each element defines how much of the local alpha reserved for the hypothesis corresponding to its row index is passed on to the hypothesis corresponding to its column index

**w**  
vector of weights, defines how much of the overall alpha is initially reserved for each elementary hypothesis

**cr**  
correlation matrix if p-values arise from one-sided tests with multivariate normal distributed test statistics for which the correlation is partially known. Unknown values can be set to NA. (See details for more information)

**al**  
overall alpha level at which the family error is controlled

**hint**  
if intersection hypotheses weights have already been computed (output of generateWeights) can be passed here otherwise will be computed during execution

**upscale**  
if FALSE (default) the parametric test is performed at the reduced level alpha of sum(w)*alpha. (See details)
Details

It is assumed that under the global null hypothesis \((\Phi^{-1}(1-p_1), ..., \Phi^{-1}(1-p_m))\) follow a multi-variate normal distribution with correlation matrix \(cr\) where \(\Phi^{-1}\) denotes the inverse of the standard normal distribution function.

For example, this is the case if \(p_1, ..., p_m\) are the raw p-values from one-sided z-tests for each of the elementary hypotheses where the correlation between z-test statistics is generated by an overlap in the observations (e.g. comparison with a common control, group-sequential analyses etc.). An application of the transformation \(\Phi^{-1}(1-p)\) to raw p-values from a two-sided test will not in general lead to a multivariate normal distribution. Partial knowledge of the correlation matrix is supported. The correlation matrix has to be passed as a numeric matrix with elements of the form: 

\[correlation[i,i] = 1\] for diagonal elements, \(correlation[i,j] = \rho_{ij}\), where \(\rho_{ij}\) is the known value of the correlation between \(\Phi^{-1}(1-p_i)\) and \(\Phi^{-1}(1-p_j)\) or NA if the corresponding correlation is unknown. For example \(correlation[1,2]=0\) indicates that the first and second test statistic are uncorrelated, whereas \(correlation[2,3] = NA\) means that the true correlation between statistics two and three is unknown and may take values between -1 and 1. The correlation has to be specified for complete blocks (i.e.: if \(cor(i,j),\) and \(cor(i,k)\) for \(i\neq j\neq k\) are specified then \(cor(j,k)\) has to be specified as well) otherwise the corresponding intersection null hypotheses tests are not uniquely defined and an error is returned.

The parametric tests in (Bretz et al. (2011)) are defined such that the tests of intersection null hypotheses always exhaust the full alpha level even if the sum of weights is strictly smaller than one. This has the consequence that certain test procedures that do not test each intersection null hypothesis at the full level alpha may not be implemented (e.g., a single step Dunnett test). If upscale is set to FALSE (default) the parametric tests are performed at a reduced level alpha of \(\sum(w) \times \alpha\) and p-values adjusted accordingly such that test procedures with non-exhaustive weighting strategies may be implemented. If set to TRUE the tests are performed as defined in Equation (3) of (Bretz et al. (2011)).

Value

Returns a matrix of rejection bounds. Each row corresponds to an intersection hypothesis. The intersection corresponding to each line is given by conversion of the line number into binary (e.g. 13 is binary 1101 and corresponds to (H1,H2,H4))

Author(s)

Florian Klinglmueller

References


Examples

```r
## Define some graph as matrix
g <- matrix(c(0,0,1,0,
            0,0,0,1,
            0,1,0,0,
            1,0,0,0), nrow = 4, byrow = TRUE)
## Choose weights
w <- c(.5,.5,0,0)
## Some correlation (upper and lower first diagonal 1/2)
c <- diag(4)
c[1:2,3:4] <- NA
c[3:4,1:2] <- NA
c[1,2] <- 1/2
c[2,1] <- 1/2
c[3,4] <- 1/2
c[4,3] <- 1/2

## Boundaries for correlated test statistics at alpha level .05:
generateBounds(g, w, c, .05)
```

Description

compute adjusted p-values either for the closed test defined by the graph or for each elementary hypotheses within each intersection hypotheses

Usage

`generatePvals(g, w, cr, p, adjusted = TRUE, hint = generateWeights(g, w), upscale = FALSE)`

Arguments

| g          | graph defined as a matrix, each element defines how much of the local alpha reserved for the hypothesis corresponding to its row index is passed on to the hypothesis corresponding to its column index |
| w          | vector of weights, defines how much of the overall alpha is initially reserved for each elementary hypothesis |
| cr         | correlation matrix if p-values arise from one-sided tests with multivariate normal distributed test statistics for which the correlation is partially known. Unknown values can be set to NA. (See details for more information) |
| p          | vector of observed unadjusted p-values, that belong to test-statistics with a joint multivariate normal null distribution with (partially) known correlation matrix cr |
adjusted logical, if TRUE (default) adjusted p-values for the closed test are returned, else a matrix of p-values adjusted only for each intersection hypothesis is returned

hint if intersection hypotheses weights have already been computed (output of \texttt{generateWeights}) can be passed here otherwise will be computed during execution

upscale if \texttt{FALSE} (default) the p-values are additionally adjusted for the case that non-exhaustive weights are specified. (See details)

### Details

It is assumed that under the global null hypothesis \((\Phi^{-1}(1-p_1), \ldots, \Phi^{-1}(1-p_m))\) follow a multivariate normal distribution with correlation matrix \(cr\) where \(\Phi^{-1}\) denotes the inverse of the standard normal distribution function.

For example, this is the case if \(p_1, \ldots, p_m\) are the raw p-values from one-sided z-tests for each of the elementary hypotheses where the correlation between z-test statistics is generated by an overlap in the observations (e.g. comparison with a common control, group-sequential analyses etc.). An application of the transformation \(\Phi^{-1}(1-p_i)\) to raw p-values from a two-sided test will not in general lead to a multivariate normal distribution. Partial knowledge of the correlation matrix is supported. The correlation matrix has to be passed as a numeric matrix with elements of the form: \(cr[i,i] = 1\) for diagonal elements, \(cr[i,j] = \rho_{ij}\), where \(\rho_{ij}\) is the known value of the correlation between \(\Phi^{-1}(1-p_i)\) and \(\Phi^{-1}(1-p_j)\) or \(\text{NA}\) if the corresponding correlation is unknown. For example \(cr[1,2]=0\) indicates that the first and second test statistic are uncorrelated, whereas \(cr[2,3] = \text{NA}\) means that the true correlation between statistics two and three is unknown and may take values between -1 and 1. The correlation has to be specified for complete blocks (i.e.: if cor(i,j), and cor(i,k) for i!=j!=k are specified then cor(j,k) has to be specified as well) otherwise the corresponding intersection null hypotheses tests are not uniquely defined and an error is returned.

The parametric tests in (Bretz et al. (2011)) are defined such that the tests of intersection null hypotheses always exhaust the full alpha level even if the sum of weights is strictly smaller than one. This has the consequence that certain test procedures that do not test each intersection null hypothesis at the full level alpha may not be implemented (e.g., a single step Dunnett test). If \texttt{upscale} is set to \texttt{FALSE} (default) the parametric tests are performed at a reduced level alpha of \(\text{sum(w)} * \alpha\) and p-values adjusted accordingly such that test procedures with non-exhaustive weighting strategies may be implemented. If set to \texttt{TRUE} the tests are performed as defined in Equation (3) of (Bretz et al. (2011)).

### Value

If \texttt{adjusted} is set to \texttt{TRUE} returns a vector of adjusted p-values. Any elementary null hypothesis is rejected if its corresponding adjusted p-value is below the predetermined alpha level. For adjusted set to \texttt{FALSE} a matrix with p-values adjusted only within each intersection hypotheses is returned. The intersection corresponding to each line is given by conversion of the line number into binary (e.g. 13 is binary 1101 and corresponds to \((H1,H2,H4)\)). If any adjusted p-value within a given line falls below alpha, then the corresponding intersection hypotheses can be rejected.

### Author(s)

Florian Klinglmüeller
References


Examples

```r
## Define some graph as matrix
cc <- matrix(c(0,0,1,0, 0,0,0,1, 0,1,0,0, 1,0,0,0), nrow = 4, byrow=TRUE)
## Choose weights
w <- c(.5,.5,0,0)
## Some correlation (upper and lower first diagonal 1/2)
c <- diag(4)
c[1:2,3:4] <- NA
c[3:4,1:2] <- NA
c[1,2] <- 1/2
c[2,1] <- 1/2
c[3,4] <- 1/2
c[4,3] <- 1/2
## p-values as Section 3 of Bretz et al. (2011),
p <- c(0.0121,0.0337,0.0084,0.0160)

## Boundaries for correlated test statistics at alpha level .05:
generatePvals(g,w,c,p)

## <- Entangled2Maurer2012()
generatePvals(g=g, cr=diag(5), p=rep(0.1,5))
```

generateTest

Description

generates a test function for the multiple comparison procedure with correlated test statistics defined by a graph

Usage

generateTest(g, w, cr, al)

Arguments

g
graph defined as a matrix, each element defines how much of the local alpha reserved for the hypothesis corresponding to its row index is passed on to the hypothesis corresponding to its column index

w
vector of weights, defines how much of the overall alpha is initially reserved for each elementary hypothesis
correlation matrix if p-values arise from one-sided tests with multivariate normal distributed test statistics for which the correlation is partially known. Unknown values can be set to NA. (See details for more information)

overall alpha level at which the family error is controlled

Details

It is assumed that under the global null hypothesis \((\Phi^{-1}(1 - p_1), ..., \Phi^{-1}(1 - p_m))\) follow a multivariate normal distribution with correlation matrix \(cr\) where \(\Phi^{-1}\) denotes the inverse of the standard normal distribution function.

For example, this is the case if \(p_1, ..., p_m\) are the raw p-values from one-sided z-tests for each of the elementary hypotheses where the correlation between z-test statistics is generated by an overlap in the observations (e.g., comparison with a common control, group-sequential analyses etc.). An application of the transformation \(\Phi^{-1}(1 - p_i)\) to raw p-values from a two-sided test will not in general lead to a multivariate normal distribution. Partial knowledge of the correlation matrix is supported. The correlation matrix has to be passed as a numeric matrix with elements of the form: \(cr[i, i] = 1\) for diagonal elements, \(cr[i, j] = \rho_{ij}\), where \(\rho_{ij}\) is the known value of the correlation between \(\Phi^{-1}(1 - p_i)\) and \(\Phi^{-1}(1 - p_j)\) or NA if the corresponding correlation is unknown. For example \(cr[1,2]=0\) indicates that the first and second test statistic are uncorrelated, whereas \(cr[2,3] = NA\) means that the true correlation between statistics two and three is unknown and may take values between -1 and 1. The correlation has to be specified for complete blocks (i.e.: if \(cor(i,j), \text{ and cor}(i,k)\) for \(i!=j!=k\) are specified then \(cor(j,k)\) has to be specified as well) otherwise the corresponding intersection null hypotheses tests are not uniquely defined and an error is returned.

The parametric tests in (Bretz et al. (2011)) are defined such that the tests of intersection null hypotheses always upscale the full alpha level even if the sum of weights is strictly smaller than one. This has the consequence that certain test procedures that do not test each intersection null hypothesis at the full level alpha may not be implemented (e.g., a single step Dunnett test). If \(upscale\) is set to FALSE (default) the parametric tests are performed at a reduced level alpha of \(\text{sum}(w) \times \alpha\) and p-values adjusted accordingly such that test procedures with non-exhaustive weighting strategies may be implemented. If set to TRUE the tests are performed as defined in Equation (3) of (Bretz et al. (2011)).

Value

Returns a function that will take a vector of z-scores to which the test will be applied. This function in turn will return a boolean vector with elements false if the particular elementary hypothesis can not be rejected and true otherwise.

Author(s)

Florian Klinglmueller

References

generateWeights

Examples

## Define some graph as matrix
```r
g <- matrix(c(0,0,1,0,  
             0,0,0,1,  
             0,1,0,0,  
             1,0,0,0), nrow = 4, byrow = TRUE)
```

## Choose weights
```r
w <- c(0.5, 0.5, 0, 0)
```

## Some correlation (upper and lower first diagonal 1/2)
```r
c <- diag(4)
c[1:2, 3:4] <- NA
c[3:4, 1:2] <- NA
c[1, 2] <- 1/2
c[2, 1] <- 1/2
c[3, 4] <- 1/2
c[4, 3] <- 1/2
```

## Test function for further use:
```r
myTest <- generateTest(g, w, c, .05)
myTest(c(3, 2, 1, 2))
```

generateWeights generateWeights

description

calculate Weights for each intersection Hypotheses in the closure of a graph based multiple testing procedure

Usage

```r
generateWeights(g, w)
```

Arguments

- **g**
  
  Graph either defined as a matrix (each element defines how much of the local alpha reserved for the hypothesis corresponding to its row index is passed on to the hypothesis corresponding to its column index), as graphMCP object or as entangledMCP object.

- **w**
  
  Vector of weights, defines how much of the overall alpha is initially reserved for each elementary hypothesis. Can be missing if \( g \) is a graphMCP object (in which case the weights from the graph object are used). Will be ignored if \( g \) is an entangledMCP object (since then the matrix of weights from this object is used).
getJavaInfo

Description

Get Memory and Runtime Info from JVM

Usage

getJavaInfo(memory = TRUE, filesystem = TRUE, runtime = TRUE)

Arguments

memory Logical whether to include memory information + number of available cores
filesystem Logical whether to include filesystem information (Total, free and usable space)
runtime Logical whether to include runtime information (Class Path, Library Path, Input Arguments)
Value

character vector of length 1 containing the memory and runtime info.

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

Examples

cat(getJavaInfo())

Arguments

gmcp (graph, pvalues, test, correlation, alpha = 0.05, approxEps = TRUE,
eps = 10^(-3), ..., upscale = ifelse(missing(test) &
!missing(correlation) || !missing(test) & test == "Bretz2011", TRUE, FALSE),
useC = FALSE, verbose = FALSE, keepWeights = TRUE, adjPValues = TRUE)

description

Performs a graph based multiple test procedure for a given graph and unadjusted p-values.

Usage

gmcp(graph, pvalues, test, correlation, alpha = 0.05, approxEps = TRUE,
eps = 10^(-3), ..., upscale = ifelse(missing(test) &
!missing(correlation) || !missing(test) & test == "Bretz2011", TRUE, FALSE),
useC = FALSE, verbose = FALSE, keepWeights = TRUE, adjPValues = TRUE)

Arguments

graph A graph of class graphMCP.
pvalues A numeric vector specifying the p-values for the graph based MCP. Note the assumptions in the details section for the parametric tests, when a correlation is specified.
test Should be either "Bonferroni", "Simes" or "parametric". If not specified by default the Bonferroni-based test procedure is used if no correlation is specified or the algorithm from Bretz et al. 2011 if a correlation is specified. If test is set to "Simes" the weighted Simes test will be performed for each subset of hypotheses.
correlation Optional correlation matrix. If the weighted Simes test is performed, it is checked whether type I error rate can be ensured and a warning is given if this is not the case. For parametric tests the p-values must arise from one-sided tests with multivariate normal distributed test statistics for which the correlation is (partially) known. In that case a weighted parametric closed test is performed (also see generatePvals). Unknown values can be set to NA. (See details for more information)
alpah A numeric specifying the maximal allowed type one error rate.
approxEps A boolean specifying whether epsilon values should be substituted with the value given in the parameter eps.
eps

A numeric scalar specifying a value for epsilon edges.

... Test specific arguments can be given here.

upscale

Logical. If upscale=FALSE then for each intersection of hypotheses (i.e. each subgraph) a weighted test is performed at the possibly reduced level alpha of sum(w)*alpha, where sum(w) is the sum of all node weights in this subset. If upscale=TRUE all weights are upscaled, so that sum(w)=1.

useC

Logical scalar. If TRUE neither adjusted p-values nor intermediate graphs are returned, but the calculation is sped up by using code written in C. THIS CODE IS NOT FOR PRODUCTIVE USE YET! If approxEps is FALSE and the graph contains epsilon edges, a warning is thrown and useC will be ignored.

verbose

Logical scalar. If TRUE verbose output is generated during sequentially rejection steps.

keepWeights

Logical scalar. If FALSE the weight of a node without outgoing edges is set to 0 if it is removed. Otherwise it keeps its weight.

adjPValues

Logical scalar. If FALSE no adjusted p-values will be calculated. Especially for the weighted Simes test this will result in significantly less calculations in most cases.

Details

For the Bonferroni procedure the p-values can arise from any statistical test, but if you improve the test by specifying a correlation matrix, the following assumptions apply:

It is assumed that under the global null hypothesis (Φ⁻¹(1 − p₁), ..., Φ⁻¹(1 − pₘ)) follow a multivariate normal distribution with correlation matrix correlation where Φ⁻¹ denotes the inverse of the standard normal distribution function.

For example, this is the case if p₁,...,pₘ are the raw p-values from one-sided z-tests for each of the elementary hypotheses where the correlation between z-test statistics is generated by an overlap in the observations (e.g. comparison with a common control, group-sequential analyses etc.). An application of the transformation Φ⁻¹(1 − pᵢ) to raw p-values from a two-sided test will not in general lead to a multivariate normal distribution. Partial knowledge of the correlation matrix is supported. The correlation matrix has to be passed as a numeric matrix with elements of the form: correlation[i,i] = 1 for diagonal elements, correlation[i,j] = ρᵢⱼ, where ρᵢⱼ is the known value of the correlation between Φ⁻¹(1 − pᵢ) and Φ⁻¹(1 − pⱼ) or NA if the corresponding correlation is unknown. For example correlation[1,2]=0 indicates that the first and second test statistic are uncorrelated, whereas correlation[2,3]=NA means that the true correlation between statistics two and three is unknown and may take values between -1 and 1. The correlation has to be specified for complete blocks (i.e.: if cor(i,j), and cor(i,j') for i!=j!=j' are specified then cor(j,j') has to be specified as well) otherwise the corresponding intersection null hypotheses tests are not uniquely defined and an error is returned.

For further details see the given references.

Value

An object of class gMCPResult, more specifically a list with elements

graphs  list of graphs
pvalues p-values
rejected logical whether hypotheses could be rejected
adjPValues adjusted p-values

Author(s)
Kornelius Rohmeyer <rohmeyer@small-projects.de>

References


See Also

graphMCP graphNEL

Examples

g <- BonferroniHolm(5)
gMCP(g, pvalues=c(0.01, 0.02, 0.04, 0.04, 0.7))
# Simple Bonferroni with empty graph:
g2 <- matrix2graph(matrix(0, nrow=5, ncol=5))
gMCP(g2, pvalues=c(0.01, 0.02, 0.04, 0.04, 0.7))
# With 'upscale=TRUE' equal to BonferroniHolm:
gMCP(g2, pvalues=c(0.01, 0.02, 0.04, 0.04, 0.7), upscale=TRUE)

# Entangled graphs:
g3 <- Entangled2Maurer2012()
gMCP(g3, pvalues=c(0.01, 0.02, 0.04, 0.04, 0.7), correlation=diag(5))
gMCPReport

Automatic Generation of gMCP Reports

Description

Creates a LaTeX file with a gMCP Report.

Usage

```r
gMCPReport(object, file = "", ...)
```

Arguments

- `object`: A graph of class `graphMCP` or an object of class `gMCPResult`.
- `file`: A connection, or a character string naming the file to print to. If "" (the default), the report is printed to the standard output connection (the console unless redirected by `sink`). If it is "|cmd", the output is piped to the command given by `cmd`, by opening a pipe connection [taken from the manual page of `cat`, which is called in this function].
- `...`: Arguments to be passed to method `graph2latex` like `package` and `scale`.

Details

This function uses `cat` and `graph2latex`.

Value

None (invisible `NULL`).

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

References


See Also

`cat` `graph2latex`

Examples

```r
g <- BrezEtAl2011()
result <- gMCP(g, pvalues=c(0.1, 0.008, 0.005, 0.15, 0.04, 0.006))
gMCPReport(result)
```
**gMCPResult-class**

**Class gMCPResult**

---

**Description**

A `gMCPResult` object describes an evaluated sequentially rejective multiple test procedure.

**Slots**

- `graphs`: Object of class `list`.
- `alpha`: A numeric specifying the maximal type I error rate.
- `pvalues`: The numeric vector of pvalues.
- `rejected`: The logical vector of rejected null hypotheses.
- `adjPValues`: The numeric vector of adjusted pvalues.

**Author(s)**

Kornelius Rohmeyer <rohmeyer@small-projects.de>

**See Also**

`gMCP`

---

**gPADInterim-class**

**Class gPADInterim**

---

**Description**

A `gPADInterim` object describes an object holding interim information for an adaptive procedure that is based on a preplanned graphical procedure.

**Slots**

- `aj`: Object of class `numeric`. Giving partial conditional errors (PCEs) for all elementary hypotheses in each intersection hypothesis
- `bj`: A numeric specifying the sum of PCEs per intersection hypothesis.
- `z1`: The numeric vector of first stage z-scores.
- `v`: A numeric specifying the proportion of measurements collected up to interim
- `preplanned`: Object of class `graphMCP` specifying the preplanned graphical procedure.
- `alpha`: A numeric giving the alpha level of the pre-planned test
Author(s)
Florian Klinglmueller <float@lefant.net>

See Also
gMCP, doInterim, secondStageTest

---

graph2latex  

Graph2\LaTeX

Description
Creates \LaTeX\ code that represents the given graph.

Usage

\begin{verbatim}
graph2latex(graph, package = "TikZ", scale = 1, showAlpha = FALSE,
    alpha = 0.05, pvalues, fontsize, nodeTikZ,
    labelTikZ = "near start,above,fill=blue!20", tikzEnv = TRUE,
    offset = c(0, 0), fill = list(reject = "red!80", retain = "green!80"),
    fig = FALSE, fig.label = NULL, fig.caption = NULL, nodeR = 25,
    scaleText = TRUE)
\end{verbatim}

Arguments

- **graph**: A graph of class `graphMCP`.
- **package**: A character string specifying the \LaTeX\ package that should be used. Up to now only TikZ is available.
- **scale**: A numeric scalar specifying a possible scaling of the graph. Note that this does not effect the fontsize of the graph. Is only used if `tikzEnv=TRUE`. (Coordinates are interpreted in big points: 72 bp = 1 inch).
- **showAlpha**: Logical whether local alpha levels or weights should be shown.
- **alpha**: An optional numeric argument to specify the type I error rate.
- **pvalues**: If the optional numeric argument `pvalues` is given, nodes that can be rejected, will be marked.
- **fontsize**: An optional character vector specifying the fontsize for the graph, must be one of "tiny", "scriptsize", "footnotesize", "small", "normalsize", "large", "Large", "LARGE", "huge" or "Huge".
- **nodeTikZ**: A character string with additional arguments for the TikZ node command like for example `nodeTikZ="minimum size=2cm"`.
- **labelTikZ**: A character string with arguments for the TikZ node command within an edge.
- **tikzEnv**: Logical whether the \LaTeX\ code should be wrapped in a TikZ environment.
- **offset**: A numeric of length 2 specifying the x and y offset in the TikZ environment.
fill A list containing 2 elements reject and retain specifying node fill colour of rejected and retained (or not yet rejected) nodes.

fig Logical whether a figure environment should be created.

fig.label Label for figure environment (if fig==TRUE).

fig.caption Caption for figure environment (if fig==TRUE).

nodeR Radius of nodes (pixel in Java, bp in LaTeX).

scaleText Only used if scale is unequal 1 and tikzenv==TRUE. If scaleText is TRUE (the default) a scalebox environment is used. If it is FALSE the optional parameter scale from the tikzpicture environment is used and font size will not change. Note that while you easily can change the scale in the scalebox environment, it is more problematic to adjust the scale in the tikzpicture environment afterwards in the LaTeX document, since for curved edges the parameters are calculated for a certain relative node size which changes if the graph is scaled but the text size stays the same.

Details

For details see the given references.

Value

A character string that contains LaTeX code representing the given graph.

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

References


See Also

graphMCP, gMCPReport

Examples

g <- BonferroniHolm(5)

graph2latex(g)
graphAnalysis

Analysis of a gMCP-Graph

Description

Creates LaTeX code that represents the given graph.

Usage

graphAnalysis(graph, file = "")

Arguments

graph  A graph of class `graphMCP`.
file  A connection, or a character string naming the file to print to. If "" (the default), the analysis is printed to the standard output connection (the console unless redirected by `sink`). If it is "|cmd", the output is piped to the command given by `cmd`, by opening a pipe connection [taken from the manual page of `cat`, which is called in this function].

Details

In the moment it is only tested whether each node is accessible from each other node. Further analysis will be added in future versions.

Value

A character string that contains the printed analysis.

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

See Also

`graphMCP`

Examples

g <- BonferroniHolm(5)

graphAnalysis(g)
graphGUI

Graphical User Interface for graphical described multiple comparison procedures

Description

Starts a graphical user interface for the creation/modification of directed weighted graphs and applying graphical described multiple comparison procedures.

Usage

graphGUI(graph = "createdGraph", pvalues = numeric(0), grid = 0,
        debug = FALSE, experimentalFeatures = FALSE, envir = globalenv())

Arguments

graph Either a variable name for the graph, given as a character string. (If it is not a syntactically valid name, make.names is called to change it to a valid one.) Or an object of class graphMCP. If the object is modified (even just by updating the class definition or arranging the nodes) it will be saved in the specified environment (default is the global environment).

pvalues Numeric value that optionally specifies the p-values.

grid Positive integer that sets the grid size for easier placement of nodes. (Therefore grid size 1 allows unrestricted placement and disables the grid.) The default grid=0 uses the last used grid value or if the GUI is started the first time a value of 50.

ddebug Logical. If TRUE debug output is printed to the R console.

experimentalFeatures Logical. If TRUE some unfinished / insufficiently tested experimental features are available in the GUI.

envir Environment where the object graph is located and/or it should be saved (default is the global environment).

Details

See the vignette of this package for further details, since describing a GUI interface is better done with a lot of nice pictures.

The GUI can save result files if asked to, can look for a new version on CRAN (if this behaviour has been approved by the user), will change the random seed in the R session if this is specified by the user in the options (default: no) and could send bug reports if an error occurs and the user approves it.

Value

The function itself returns NULL. But with the GUI a graph can be created or edited that will be available in R under the specified variable name after saving in the specified environment.
Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

Examples

```r
## Not run:
graphGUI()
pvalues <- c(0.7, 1.5, 0.5, 0.6, 0.4, 0.8, 4)/100
graphGUI(HommelEtAl2007(), pvalues=pvalues)

x <- new.env()
assign("graph", BonferroniHolm(3), envir=x)
graphGUI("graph", envir=x)
## End(Not run)
```

---

**graphMCP-class  Class graphMCP**

**Description**

A **graphMCP** object describes a sequentially rejective multiple test procedure.

**Slots**

- `m`: A transition matrix. Can be either numerical or character depending whether the matrix contains variables or not. Row and column names will be the names of the nodes.
- `weights`: A numeric.
- `edgeAttr`: A list for edge attributes.
- `nodeAttr`: A list for node attributes.

**Methods**

- **getMatrix** signature(object = "graphMCP"): A method for getting the transition matrix of the graph.
- **getWeights** signature(object = "graphMCP"): A method for getting the weights. If a third optional argument node is specified, only for these nodes the weight will be returned.
- **setWeights** signature(object = "graphMCP"): A method for setting the weights. If a third optional argument node is specified, only for these nodes the weight will be set.
- **getRejected** signature(object = "graphMCP"): A method for getting the information whether the hypotheses are marked in the graph as already rejected. If a second optional argument node is specified, only for these nodes the boolean vector will be returned.
- **getXCoordinates** signature(object = "graphMCP"): A method for getting the x coordinates of the graph. If a second optional argument node is specified, only for these nodes the x coordinates will be returned. If x coordinates are not set yet NULL is returned.
**getYCoordinates** signature(object = "graphMCP"): A method for getting the y coordinates of the graph. If a second optional argument node is specified, only for these nodes the x coordinates will be returned. If y coordinates are not set yet NULL is returned.

**setEdge** signature(from="character", to="character", graph="graphNEL", weights="numeric"): A method for adding new edges with the given weights.

**setEdge** signature(from="character", to="character", graph="graphMCP", weights="character"): A method for adding new edges with the given weights.

**Author(s)**

Kornelius Rohmeyer <rohmeyer@small-projects.de>

**Examples**

```r
m <- rbind(H1=c(0, 0.5, 0.5, 0, 0),
           H21=c(1/3, 1/3, 0, 1/3, 0),
           H31=c(0, 0.5, 0, 0, 0.5),
           H12=c(0, 1, 0, 0, 0),
           H22=c(0.5, 0, 0.5, 0, 0),
           H32=0)

weights <- c(1/3, 1/3, 1/3, 0, 0, 0)

# Graph creation
graph <- new("graphMCP", m=m, weights=weights)

# Visualization settings
nodeX <- rep(c(100, 300, 500), 2)
nodeY <- rep(c(100, 300), each=3)

graph@nodeAttr$X <- nodeX
graph@nodeAttr$Y <- nodeY

geweights(graph)

grejected(graph)

pvalues <- c(0.1, 0.008, 0.005, 0.15, 0.04, 0.006)
result <- gMCP(graph, pvalues)

geweights(result@graphs[[4]])
grejected(result@graphs[[4]])
```

---

**graphTest**

*Multiple testing using graphs*
**Description**

Implements the graphical test procedure described in Bretz et al. (2009). Note that the gMCP function in the gMCP package performs the same task.

**Usage**

```r
graphTest(pvalues, weights = NULL, alpha = 0.05, G = NULL, cr = NULL, graph = NULL, verbose = FALSE, test, upscale = FALSE)
```

**Arguments**

- `pvalues`: Either a vector or a matrix containing the local p-values for the hypotheses in the rows.
- `weights`: Initial weight levels for the test procedure, in case of multiple graphs this needs to be a matrix.
- `alpha`: Overall alpha level of the procedure. For entangled graphs `alpha` should be a numeric vector of length equal to the number of graphs, each element specifying the partial alpha for the respective graph. The overall alpha level equals `sum(alpha)`.
- `G`: For simple graphs `G` should be a numeric matrix determining the graph underlying the test procedure. Note that the diagonal need to contain only 0s, while the rows need to sum to 1. For entangled graphs it needs to be a list containing the different graph matrices as elements.
- `graph`: As an alternative to the specification via `weights` and `G` one can also hand over a `graphMCP` object to the code. `graphMCP` objects can be created for example with the `graphGUI` function.
- `cr`: Correlation matrix that should be used for the parametric test. If `cr=NULL` the Bonferroni based test procedure is used.
- `verbose`: If `verbose` is `TRUE`, additional information about the graphical rejection procedure is displayed.
- `test`: In the parametric case there is more than one way to handle subgraphs with less than the full alpha. If the parameter `test` is missing, the tests are performed as described by Bretz et al. (2011), i.e. tests of intersection null hypotheses always exhaust the full alpha level even if the sum of weights is strictly smaller than one. If `test="simple-parametric"` the tests are performed as defined in Equation (3) of Bretz et al. (2011).
- `upscale`: Logical. If `upscale=FALSE` then for each intersection of hypotheses (i.e. each subgraph) a weighted test is performed at the possibly reduced level alpha of `sum(w)*alpha`, where `sum(w)` is the sum of all node weights in this subset. If `upscale=TRUE` all weights are upscaled, so that `sum(w)=1`.

**Value**

A vector or a matrix containing the test results for the hypotheses under consideration. Significant tests are denoted by a 1, non-significant results by a 0.
References


Examples

```r
### example from Bretz et al. (2010)
weights <- c(1/3, 1/3, 1/3, 0, 0, 0)
graph <- rbind(c(0, 0.5, 0, 0.5, 0, 0),
               c(0.5, 0.5, 0, 0, 0, 0.5),
               c(0, 1, 0, 0, 0, 0),
               c(0.5, 0.5, 0, 0, 0, 0),
               c(0, 1, 0, 0, 0, 0))
pvals <- c(0.1, 0.008, 0.005, 0.15, 0.04, 0.006)
graphTest(pvals, weights, alpha=0.025, graph)

### observe graphical procedure in detail
graphTest(pvals, weights, alpha=0.025, graph, verbose = TRUE)

### now use many p-values (useful for power simulations)
pvals <- matrix(rbeta(6e4, 1, 30), ncol = 6)
out <- graphTest(pvals, weights, alpha=0.025, graph)
head(out)

### example using multiple graphs (instead of 1)
G1 <- rbind(c(0,0.5,0.5,0,0), c(0.0,1,0,0),
            c(0, 0, 0, 1-0.01, 0.01), c(0, 1, 0, 0, 0),
            c(0, 0, 0, 0, 0))
G2 <- rbind(c(0,0.5,0.5,0,0),
            c(0, 0, 0, 1, 0.01),
            c(0, 0, 0, 0, 0),
            c(0, 0, 0, 0, 0),
            c(0, 0, 0, 0, 0))
weights <- cbind(c(1, 0, 0, 0, 0), c(0.1, 0, 0, 0, 0))
pvals <- c(0.012, 0.025, 0.005, 0.0015, 0.0045)
out <- graphTest(pvals, weights, alpha=c(0.0125, 0.0125), G=list(G1, G2), verbose = TRUE)

### now again with many p-values
pvals <- matrix(rbeta(5e4, 1, 30), ncol = 5)
out <- graphTest(pvals, weights, alpha=c(0.0125, 0.0125), G=list(G1, G2))
head(out)
```

---

hydroquinone

**Hydroquinone Mutagenicity Assay**
Description

This data set gives the number of micronuclei per animal and 2000 scored cells for six different
groups of differently treated male mice: The negative control (C-), four doses (30, 50, 75, 100 mg
hydroquinone / kg) of hydroquinone and an active control (C+) (with 25 mg/kg cyclophosphamide).

Usage

data(hydroquinone)

Format

A data frame with 31 observations on the following 2 variables:

- **group**: A factor with levels "C-", "30 mg/kg", "50 mg/kg", "75 mg/kg", "100 mg/kg" and "C+
"specifying the groups.

- **micronuclei**: A numeric vector, giving the counts of micronuclei per animal and 2000 scored cells
after 24h.

Source

Adler, I.-D. and Kliesch, U. (1990): *Comparison of single and multiple treatment regimens in
the mouse bone marrow micronucleus assay for hydroquinone and cyclophosphamide*. Mutation
Research 234, 115-123.

References

iments including active control*. Statistics in Medicine 17, 2133-2146.

Examples

data(hydroquinone)
boxplot(micronuclei~group, data=hydroquinone)

---

**joinGraphs**

Joins two graphMCP objects

Description

Creates a new graphMCP object by joining two given graphMCP objects.

Usage

joinGraphs(graph1, graph2, xOffset = 0, yOffset = 200)
Arguments

graph1 A graph of class `graphMCP`.
graph2 A graph of class `graphMCP`.
xOffset A numeric specifying an offset (on the x-axis) for placing the nodes and edge labels of the second graph.
yOffset A numeric specifying an offset (on the y-axis) for placing the nodes and edge labels of the second graph.

Details

If graph1 and graph2 have duplicates in the node names, the nodes of the second graph will be renamed.

If and only if the sum of the weights of graph1 and graph2 exceeds 1, the weights are scaled so that the sum equals 1.

A description attribute of either graph will be discarded.

Value

A graphMCP object that represents a graph that consists of the two given graphs.

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

See Also

`graphMCP`

Examples

g1 <- BonferroniHolm(2)
g2 <- BonferroniHolm(3)

joinGraphs(g1, g2)

Description

Creates a graph of class `graphMCP` from a given transition matrix or vice versa.

Usage

`matrix2graph(m, weights = rep(1/dim(m)[1], dim(m)[1]))`

`graph2matrix(graph)"
Arguments

m A transition matrix.
weights A numeric for the initial weights.
graph A graph of class graphMCP.

Details

The hypotheses names are the row names or if these are NULL, the column names or if these are also NULL of type H1, H2, H3, ...

If the diagonal of the matrix is unequal zero, the values are ignored and a warning is given.

Value

A graph of class graphMCP with the given transition matrix for matrix2graph. The transition matrix of a graphMCP graph for graph2matrix.

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

Examples

# Bonferroni-Holm:
m <- matrix(rep(1/3, 16), nrow=4)
diag(m) <- c(0, 0, 0, 0)
graph <- matrix2graph(m)
print(graph)
graph2matrix(graph)

placeNodes Placement of graph nodes

Description

Places the nodes of a graph according to a specified layout.

Usage

placeNodes(graph, nrow, ncol, byrow = TRUE, topdown = TRUE, force = FALSE)
plotSimCI

Arguments

- **graph**: A graph of class `graphMCP` or class `entangledMCP`.
- **nrow**: The desired number of rows.
- **ncol**: The desired number of columns.
- **byrow**: Logical whether the graph is filled by rows (otherwise by columns).
- **topdown**: Logical whether the rows are filled top-down or bottom-up.
- **force**: Logical whether a graph that has already a layout should be given the specified new layout.

Details

If one of `nrow` or `ncol` is not given, an attempt is made to infer it from the number of nodes of the graph and the other parameter. If neither is given, the graph is placed as a circle.

Value

The graph with nodes placed according to the specified layout.

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

See Also

- `graphMCP`
- `entangledMCP`

Examples

```r
  g <- matrix2graph(matrix(0, nrow=6, ncol=6))
  g <- placeNodes(g, nrow=2, force=TRUE)
  # Not run:
  graphGUI(g)

  # End(Not run)
```

plotSimCI  Plot confidence intervals

Description

A function for convenient plotting of confidence intervals.
Usage
plotSimCI(ci)

Arguments

\texttt{ci} \hspace{1cm} a (named) matrix containing the lower confidence bounds in the first column, the point estimates in the second and the upper confidence bounds in the third column.

Author(s)
Code adapted from \texttt{plotCII} from Frank Schaarschmidt

Examples

\begin{verbatim}
est <- c("H1"=0.860382, "H2"=0.9161474, "H3"=0.9732953)
# Sample standard deviations:
ssd <- c("H1"=0.8759528, "H2"=1.291310, "H3"=0.8570892)
pval <- c(0.01260, 0.05154, 0.02124)/2

ci <- simConfint(BonferroniHolm(3), pvalues=pval,
        confint="t", df=9, estimates=est, alpha=0.025, alternative="greater")

plotSimCI(ci)
\end{verbatim}

rejectNode \hspace{1cm} \textit{Rejects a node/hypothesis and updates the graph accordingly.}

Description
Rejects a node/hypothesis and updates the graph accordingly.

Usage

\begin{verbatim}
rejectNode(graph, node, verbose = FALSE, keepWeights = TRUE)
\end{verbatim}

Arguments

\begin{itemize}
\item \texttt{graph} \hspace{1cm} A graph of class \texttt{graphMCP} or \texttt{entangledMCP}.
\item \texttt{node} \hspace{1cm} A character string specifying the node to reject.
\item \texttt{verbose} \hspace{1cm} Logical scalar. If \texttt{TRUE} verbose output is generated during sequentially rejection steps.
\item \texttt{keepWeights} \hspace{1cm} Logical scalar. If \texttt{FALSE} the weight of a node without outgoing edges is set to \texttt{0} if it is removed. Otherwise it keeps its weight.
\end{itemize}
Details
For details see the given references.

Value
An updated graph of class `graphMCP` or `entangledMCP`.

Author(s)
Kornelius Rohmeyer <rohmeyer@small-projects.de>

References

See Also
`graphMCP`

Examples
```r
 g <- BonferroniHolm(5)
 rejectNode(g, "H1")
```

---

### replaceVariables

Replaces variables in a general graph with specified numeric values

Description
Given a list of variables and real values a general graph is processed and each variable replaced with the specified numeric value.

Usage
```
replaceVariables(graph, variables = list(), ask = TRUE, partial = FALSE)
```

Arguments
- `graph`: A graph of class `graphMCP` or `entangledMCP`.
- `variables`: A named list with the specified real values, for example `list(a=0.5, b=0.8, "tau"=0.5)`. If `ask=TRUE` and this list is missing at all or single variables are missing from the list, the user is asked for the values (if the session is not interactive an error is thrown).
- `ask`: If `FALSE` all variables that are not specified are not replaced.
- `partial`: If `TRUE` only specified variables are replaced and parameter `ask` is ignored.
Value

A graph or a matrix with variables replaced by the specified numeric values.

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

See Also

graphMCP, entangledMCP

Examples

graph <- HungEtWang2010()
## Not run:
replaceVariables(graph)

## End(Not run)
replaceVariables(graph, list("tau"=0.5,"omega"=0.5, "nu"=0.5))

rqmvnorm Random sample from the multivariate normal distribution

Description

Draw a quasi or pseudo random sample from the MVN distribution. For details on the implemented lattice rule for quasi-random numbers see Cools et al. (2006).

Usage

rqmvnorm(n, mean = rep(0, nrow(sigma)), sigma = diag(length(mean)),
         type = c("quasirandom", "pseudorandom"))

Arguments

n Number of samples, when type = "quasirandom" is used this number is rounded up to the next power of 2 (e.g. 1000 to 1024=2^10) and at least 1024.

mean Mean vector

sigma Covariance matrix

type What type of random numbers to use. quasirandom uses a randomized Lattice rule, and should be more efficient than pseudorandom that uses ordinary (pseudo) random numbers.

Value

Matrix of simulated values
Author(s)
We thank Dr. Frances Kuo for the permission to use the generating vectors (order 2 lattice rule) obtained from her website http://web.maths.unsw.edu.au/~fkuo/lattice/.

References

Examples
sims <- rvmvnorm(100, mean = 1:2, sigma = diag(2))
plot(sims)

sampSize Function for sample size calculation

Description
Function for sample size calculation

Usage
sampSize(upperN, lowerN = floor(upperN/2), targFunc, target, tol = 0.001, alRatio, Ntype = c("arm", "total"), verbose = FALSE)

Arguments
upperN targFunc(upperN) should be bigger than target (otherwise upperN is doubled until this is the case).
lowerN targFunc(lowerN) should be smaller than target (otherwise lowerN is halfed until this is the case).
targFunc The target (power) function that should be monotonically increasing in n.
target The target value. The function searches the n with targFunc(n) > target.
tol Tolerance: The function searches the n with targFunc(n) > target.
alRatio Allocation ratio.
Ntype Either "arm" or "total".
verbose Logical, whether verbose output should be printed.

Details
For details see the manual and examples.
Value

Integer value \( n \) (of type numeric) with \( \text{targFunc}(n) < \text{target} \) and \( \text{targFunc}(n) > \text{target} \).

Examples

```r
f <- function(x){1/100*log(x)}
gMCP::sampSize(upperN=1000, targFunc=f, target=0.8, verbose=TRUE, alRatio=1)
gMCP::sampSize(lowerN=1, upperN=1000, targFunc=f, target=0.8, verbose=TRUE, alRatio=1)
```

**secondStageTest**

EXPERIMENTAL: Construct a valid level alpha test for the second stage of an adaptive design that is based on a pre-planned graphical MCP

Description

Based on a pre-planned graphical multiple comparison procedure, construct a valid multiple level alpha test that conserves the family wise error in the strong sense regardless of any trial adaptations during an unblinded interim analysis. - Implementation of adaptive procedures is still in an early stage and may change in the near future

Usage

```r
secondStageTest(interim, select, matchCE = TRUE, zWeights = "reject",
    G2 = interim@preplanned)
```

Arguments

- **interim**: An object of class \texttt{gPADInterim}.
- **select**: A logical vector giving specifying which hypotheses are carried forward to the second stage.
- **matchCE**: Logical specifying whether second stage weights should be computed proportional to corresponding PCEs.
- **zWeights**: Either "reject", "accept", or "strict" giving the rule what should be done in cases where none of the selected hypotheses has positive second stage weight.
- **G2**: An object of class \texttt{graphMCP} laying down the rule to compute second stage weights. Defaults to pre-planned graph.

Details

For details see the given references.

Value

A function of signature \texttt{function(z2)} with arguments \( z2 \) a numeric vector with second stage \( z \)-scores (\( Z \)-scores of dropped hypotheses should be set no \texttt{NA}) that returns objects of class \texttt{gMCPResult}. 
Author(s)

Florian KlinglmueLLer <float@lefant.net>

References


Posch M, Maurer W, Bretz F (2010): Type I error rate control in adaptive designs for confirmatory clinical trials with treatment selection at interim Pharm Stat 10/2, 96-104

See Also

graphMCP, doInterim

Examples

```r
## Simple successive graph (Maurer et al. 2011)
## two treatments two hierarchically ordered endpoints
a <- .025
G <- simpleSuccessiveI()
## some z-scores:
p1=c(.1,.12,.21,.16)
z1 <- qnorm(1-p1)
p2=c(.04,1,.14,1)
z2 <- qnorm(1-p2)
v <- c(1/2,1/3,1/2,1/3)
intA <- doInterim(G,z1,v)

## select only the first treatment
fTest <- secondStageTest(intA,c(1,0,1,0))
```

**Description**

Calculates simultaneous confidence intervals for sequentially rejective multiple test procedures.
Usage

simConfint(object, pvalues, confint, alternative=c("less", "greater"),
estimates, df, alpha=0.05, mu=0)

Arguments

object A graph of class graphMCP.
pvalues A numeric vector specifying the p-values for the sequentially rejective MTP.
confint One of the following: A character string "normal", "t" or a function that calculates the confidence intervals. If confint="t" the parameter df must be specified. If confint is a function it must be of signature ("character", "numeric"), where the first parameter is the hypothesis name and the second the marginal confidence level (see examples).
alternative A character string specifying the alternative hypothesis, must be "greater" or "less".
estimates Point estimates for the parameters of interest.
df Degree of freedom as numeric.
alpha The overall alpha level as numeric scalar.
mu The numerical parameter vector under null hypothesis.

Details

For details see the given references.

Value

A matrix with columns giving lower confidence limits, point estimates and upper confidence limits for each parameter. These will be labeled as "lower bound", "estimate" and "upper bound".

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

References


See Also

graphMCP
Examples

```r
est <- c("H1"=0.860382, "H2"=0.9161474, "H3"=0.9732953)
# Sample standard deviations:
ssd <- c("H1"=0.8759528, "H2"=1.291310, "H3"=0.8570892)
pval <- c(0.01260, 0.05154, 0.02124)/2

simConfint(BonferroniHolm(3), pvalues=pval, confint=function(node, alpha) {
c(est[node]-qt(1-alpha,df=9)*ssd[node]/sqrt(10), Inf)
}, estimates=est, alpha=0.025, mu=0, alternative="greater")

# Note that the sample standard deviations in the following call
# will be calculated from the pvalues and estimates.
ci <- simConfint(BonferroniHolm(3), pvalues=pval, confint="t", df=9, estimates=est, alpha=0.025, alternative="greater")
ci

plotSimCI(ci)
```

---

**Simvastatin**

*Simvastatin and Colesevelam Treatment in Patients with Primary Hypercholesterolemia*

**Description**

This data set gives the results from a study investigating the efficacy and safety of simvastatin and colesevelam treatment in patients with primary hypercholesterolemia. It shows the sample sizes, the mean LDL cholesterol levels and the number of patients with adverse events after 6 weeks. The treatment groups are: The Placebo control, two doses 10 mg and 20 mg of simvastatin and an combined treatment 20 mg + 2.3 g colesevelam.

**Usage**

data(simvastatin)

**Format**

A data frame with a summary table for ...:

- **group** A factor with levels "Placebo", "10 mg", "20 mg", "20 mg + 2.3 g Colesevelam" specifying the groups.
- **sampleSize** A numeric vector, giving the number of patients in the groups.
- **means** A numeric vector, giving the mean LDL cholesterol levels.
- **sd** A numeric vector, giving the standard deviation of the LDL cholesterol levels.
- **adverseEvents** An integer vector, giving the number of patients with adverse events after 6 weeks.
Source


References


Examples

```r
data(simvastatin)
barplot(simvastatin$means, names.arg=simvastatin$group)
```

**subgraph**

*Get a subgraph*

**Description**

Given a set of nodes and a graph this function creates the subgraph containing only the specified nodes.

**Usage**

```r
subgraph(graph, subset)
```

**Arguments**

- **graph** A graph of class `graphMCP`.
- **subset** A logical or character vector specifying the nodes in the subgraph.

**Value**

A subgraph containing only the specified nodes.

**Author(s)**

Kornelius Rohmeyer <rohmeyer@small-projects.de>

**See Also**

`graphMCP`
substituteEps

Examples

```r
graph <- improvedParallelGatekeeping()
subgraph(graph, c(TRUE, FALSE, TRUE, FALSE))
subgraph(graph, c("H1", "H3"))
```

---

### substituteEps

**Substitute Epsilon**

#### Description

Substitute Epsilon with a given value.

#### Usage

```r
substituteEps(graph, eps = 10^-3)
```

#### Arguments

- `graph` (A graph of class `graphMCP` or class `entangledMCP`.)
- `eps` (A numeric scalar specifying a value for epsilon edges.)

#### Details

For details see the given references.

#### Value

A graph where all epsilons have been replaced with the given value.

#### Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>

#### See Also

`graphMCP, entangledMCP`

#### Examples

```r
graph <- improvedParallelGatekeeping()
graph
substituteEps(graph, eps=0.01)
```
unitTestsGMCP  

Run the R unit (and optional the JUnit) test suite for gMCP

Description

Runs the R unit (and optional the JUnit) test suite for gMCP and prints the results.

Usage

unitTestsGMCP(extended = FALSE, java = FALSE, interactive = FALSE, junitLibrary, outputPath)

Arguments

- **extended**: If TRUE (or if the environment variable GMCP_UNIT_TESTS equals "extended" or "all") an extended version of the R unit test suite for gMCP will be used. The run will take significantly longer time.
- **java**: If TRUE (or if the environment variable GMCP_UNIT_TESTS equals "java" or "all") the GUI and its logic is tested with JUnit tests. You need JUnit 4 classes in the classpath or specify the path to a JUnit 4 jar file via the parameter junitLibrary.
- **interactive**: If TRUE (or if the environment variable GMCP_UNIT_TESTS equals "interactive" or "all") the interactive part of the RUnit tests is run. The user have to look at results and answer questions.
- **junitLibrary**: A character String specifying the path to a JUnit 4 jar file to run the JUnit tests. You can download it from [http://www.junit.org/](http://www.junit.org/). Alternatively you can use the environment variable GMCP_JUNIT_LIBRARY to specify the path.
- **outputPath**: During the RUnit tests files maybe produced at this location. If missing the current working directory is used if nothing else is specified in the environment variable GMCP_UNIT_TEST_OPATH.

Details

The environment variable GMCP_UNIT_TESTS may be used to specify which unit tests should run: "extended", "interactive", "java" or a combination of these separated by comma (without blanks). A short cut for all three is "all".

Value

None of interest so far - the function prints the results to the standard output. (Perhaps in future versions a value will be returned that can be processed by the GUI.)

Author(s)

Kornelius Rohmeyer <rohmeyer@small-projects.de>
Examples

```r
## Not run:
unitTestsForGMCP()
unitTestsGMCP(extended=TRUE, java=TRUE, interactive=TRUE, outputPath="~/RUnitTests")

## End(Not run)
```
Index

*Topic IO
  gMCPReport, 26
*Topic datasets
  hydroquinone, 35
  simvastatin, 47
*Topic distribution
  rqmvnorm, 42
*Topic file
  gMCPReport, 26
*Topic graphs
  corMatWizard, 7
doInterim, 8
  entangledMCP-class, 10
  exampleGraphs, 11
gMCP, 23
gMCP-package, 2
gMCPReport, 26
gMCPResult-class, 27
gPADInterim-class, 27
graph2latex, 28
graphAnalysis, 30
graphGUI, 31
graphMCP-class, 32
  joinGraphs, 36
  matrix2graph, 37
  placeNodes, 38
  rejectNode, 40
  replaceVariables, 41
  secondStageTest, 44
  simConfint, 45
  subgraph, 48
  substituteEps, 49
*Topic hplot
  plotsimCI, 39
*Topic htest
  calcPower, 5
doInterim, 8
  extractPowers, 14
  generateBounds, 15
  generatePvals, 17
  generateTest, 19
  generateWeights, 21
gMCP, 23
gMCP-package, 2
graphTest, 33
  rejectNode, 40
  secondStageTest, 44
  simConfint, 45
*Topic misc
  corMatWizard, 7
eXampleGraphs, 11
  graphGUI, 31
*Topic package
  gMCP-package, 2
*Topic print
  gMCPReport, 26
graph2latex, 28
  replaceVariables, 41
  subgraph, 48
  substituteEps, 49
BauerEtAl2001 (exampleGraphs), 11
bdiaNA, 4
body, 13
BonferroniHolm (exampleGraphs), 11
BretzEtAl2009a (exampleGraphs), 11
BretzEtAl2009b (exampleGraphs), 11
BretzEtAl2009c (exampleGraphs), 11
BretzEtAl2011 (exampleGraphs), 11
calcPower, 5
cat, 26
corMatWizard, 7
cycleGraph (exampleGraphs), 11
doInterim, 8, 28, 45
edgeAttr (graphMCP-class), 32
edgeAttr, graphMCP, character, character, character-method
  (graphMCP-class), 32
INDEX

edgeAttr <- (graphMCP-class), 32
eedgeAttr <- , graphMCP, character, character, character-character-method (graphMCP-class), 32
EntangledMaurer2012 (exampleGraphs), 11
Entangled2Maurer2012 (exampleGraphs), 11
entangledMCP (entangledMCP-class), 10
entangledMCP-class, 10
exampleGraphs, 11
extractPower, 14

fallback (exampleGraphs), 11
Ferber2011 (exampleGraphs), 11
FerberTimeDose2011 (exampleGraphs), 11
fixedSequence (exampleGraphs), 11
generalSuccessive (exampleGraphs), 11
generateBounds, 15
generatePvals, 17, 23
generateTest, 19
generateWeights, 15, 18, 21
getJavaInfo, 22
getMatrices (entangledMCP-class), 10
getMatrices, entangledMCP-method (entangledMCP-class), 10
getMatrix (graphMCP-class), 32
getMatrix, graphMCP-method (graphMCP-class), 32
getNodes (graphMCP-class), 32
getNodes, entangledMCP-method (entangledMCP-class), 10
getNodes, graphMCP-method (graphMCP-class), 32
getRejected (graphMCP-class), 32
getRejected, entangledMCP-method (entangledMCP-class), 10
getRejected, gMCPResult-method (gMCPResult-class), 27
getRejected, gPADInterim-method (gPADInterim-class), 27
getWeights (graphMCP-class), 32
getWeights, entangledMCP-method (entangledMCP-class), 10
getWeights, gMCPResult-method (gMCPResult-class), 27
getWeights, gPADInterim-method (gPADInterim-class), 27

HommeEtAl2007 (exampleGraphs), 11
HommeEtAl2007Simple (exampleGraphs), 11
HungEtWang2010 (exampleGraphs), 11
HuqueAloshEtBhore2011 (exampleGraphs), 11
hydroquinone, 35

improvedFallbackI (exampleGraphs), 11
improvedFallbackII (exampleGraphs), 11
improvedParallelGatekeeping (exampleGraphs), 11
joinGraphs, 36

make.names, 31
matrix2graph, 3, 37
MaurerEtAl1995 (exampleGraphs), 11
INDEX

nodeAttr (graphMCP-class), 32
nodeAttr, graphMCP, character, character-method
   (graphMCP-class), 32
nodeAttr<- (graphMCP-class), 32
nodeAttr<-, graphMCP, character, character-method
   (graphMCP-class), 32

parallelGatekeeping (exampleGraphs), 11
placeNodes, 38
plot, gMCPResult, ANY-method
   (gMCPResult-class), 27
plot, gPADInterim-method
   (gPADInterim-class), 27
plot, graphMCP, ANY-method
   (graphMCP-class), 32
plotSimCI, 39
print, entangledMCP-method
   (entangledMCP-class), 10
print, gMCPResult-method
   (gMCPResult-class), 27
print, gPADInterim-method
   (gPADInterim-class), 27
print, graphMCP-method (graphMCP-class),
   32

rejectNode, 40
replaceVariables, 41
rqmvnorm, 42

sampSize, 43
secondStageTest, 9, 28, 44
setEdge (graphMCP-class), 32
setEdge, character, character, graphMCP, character-method
   (graphMCP-class), 32
setEdge, character, character, graphMCP, numeric-method
   (graphMCP-class), 32
setRejected<- (graphMCP-class), 32
setRejected<-, graphMCP-method
   (graphMCP-class), 32
setWeights (graphMCP-class), 32
setWeights, graphMCP-method
   (graphMCP-class), 32
simConfint, 45
simConfint, graphMCP-method
   (simConfint), 45
simpleSuccessiveI (exampleGraphs), 11
simpleSuccessiveII (exampleGraphs), 11
simvastatin, 47
subgraph, 48