Package ‘DEGraph’

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Title Two-sample tests on a graph
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Author Laurent Jacob, Pierre Neuvial and Sandrine Dudoit
Maintainer Laurent Jacob <laurent.jacob@gmail.com>

Description DEGraph implements recent hypothesis testing methods which directly assess whether a particular gene network is differentially expressed between two conditions. This is to be contrasted with the more classical two-step approaches which first test individual genes, then test gene sets for enrichment in differentially expressed genes. These recent methods take into account the topology of the network to yield more powerful detection procedures. DEGraph provides methods to easily test all KEGG pathways for differential expression on any gene expression data set and tools to visualize the results.

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LazyLoad yes

Imports graph, KEGGgraph, lattice, mvtnorm, R.methodsS3, RBGL, Rgraphviz, rrcov, NCIgraph
Suggests corpcor, fields, graph, KEGGgraph, lattice, marray, RBGL, rrcov, Rgraphviz, NCIgraph
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NeedsCompilation no

R topics documented:

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AN.test

AN.test

Performs the Adaptive Neyman test of Fan and Lin (1998)

Description


Usage

AN.test(X1, X2, candK=1:ncol(X1), na.rm=FALSE)

Arguments

X1 A n1 x p matrix, observed data for class 1: p variables, n1 observations.
X2 A n2 x p matrix, observed data for class 2: p variables, n2 observations.
candK A vector, candidate values for the true number of Fourier components.
na.rm A logical value indicating whether variables with NA in at least one of the n1 + n2 observations should be discarder before the test is performed.

Value

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

statistic A numeric value, the test statistic.
p.value A numeric value, the corresponding p-value.
kstar A numeric value, the estimated true number of Fourier components.

Author(s)

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

See Also

BS.test() graph.T2.test() hyper.test()
Examples

```r
library("KEGGgraph")
## library("NCIgraph")
library("rrcov")
data("Loi2008_DEGraphVignette")
exprData <- exprLoi2008
classData <- classLoi2008
rn <- rownames(exprData)

## Retrieve expression levels data for genes from one KEGG pathway
gr <- grListKEGG[[1]]
gids <- translateKEGGID2GeneID(nodes(gr))
mm <- match(gids, rownames(exprData))

## Keep genes from the graph that are present in the expression data set
idxs <- which(!is.na(mm))
gr <- subGraph(nodes(gr)[idxs], gr)

idxs <- which(is.na(mm))
if(length(idxs)) {
  print("Gene ID not found in expression data: ")
  str(gids[idxs])
}
dat <- exprData[na.omit(mm), ]
str(dat)

X1 <- t(dat[, classData==0])
X2 <- t(dat[, classData==1])

## DEGraph T2 test
res <- testOneGraph(gr, exprData, classData, verbose=TRUE, prop=0.2)

## T2 test (Hotelling)
rT2 <- T2.test(X1, X2)
str(rT2)

## Adaptive Neyman test
rAN <- AN.test(X1, X2, na.rm=TRUE)
str(rAN)

## Adaptive Neyman test from Fan and Lin (1998)
rAN <- AN.test(X1, X2, na.rm=TRUE)
str(rAN)

## Test from Bai and Saranadasa (1996)
rBS <- BS.test(X1, X2, na.rm=TRUE)
str(rBS)

## Hypergeometric test
pValues <- apply(exprData, 1, FUN=function(x) {
  tt <- t.test(x[classData==0], x[classData==1])
  tt$p.value
})
str(pValues)
names(pValues) <- rownames(exprData)
```
rHyper <- hyper.test(pValues, gids, thr=0.01)
str(rHyper)

##

**annLoi2008**

*Annotation data used in the DEGraph package vignette*

### Description

This data set gives NCBI, Hugo and alternative gene symbols along with the cytoband and description for the 227 genes used in the DEGraph package vignette. This comes from the 15737 gene, 255 patient dataset of Loi et al. (2008) which was used to study resistance to tamoxifen treatment in hormone-dependent breast cancer.

### Usage

annLoi2008

### Format

A matrix of 227 lines and 5 columns.

### Author(s)

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

### Source


### References


### Examples

data("Loi2008_DEGraphVignette")
dim(annLoi2008)
head(annLoi2008)
BS.test  

Performs the test of Bai and Saranadasa (1996)

Description

Performs the test of Bai and Saranadasa (1996).

Usage

BS.test(X1, X2, na.rm=FALSE)

Arguments

X1  A n1 x p matrix, observed data for class 1: p variables, n1 observations.
X2  A n2 x p matrix, observed data for class 2: p variables, n2 observations.
na.rm  A logical value indicating whether variables with NA in at least one of the n1 + n2 observations should be discarded before the test is performed.

Value

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

statistic  A numeric value, the test statistic.
p.value  A numeric value, the corresponding p-value.

Author(s)

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

See Also

AN.test() graph.T2.test() hyper.test()

Examples

library("KEGGgraph")
## library("NCIgraph")
library("rrcov")

data("Loi2008_DEGraphVignette")
exprData <- exprLoi2008
classData <- classLoi2008
rn <- rownames(exprData)

## Retrieve expression levels data for genes from one KEGG pathway
gr <- grListKEGG[[1]]
gids <- translateKEGGID2GeneID(nodes(gr))
mm <- match(gids, rownames(exprData))

## Keep genes from the graph that are present in the expression data set
idxs <- which(!is.na(mm))
gr <- subGraph(nodes(gr)[idxs], gr)
classLoi2008

Tamoxifen treatment resistance status data used in the DEGraph package vignette

Description

This data set gives resistance status data for the 255 patients used in the DEGraph package vignette. This comes from the 15737 gene, 255 patient dataset of Loi et al. (2008) which was used to study resistance to tamoxifen treatment in hormone-dependent breast cancer.

Usage

classLoi2008

idxs <- which(is.na(mm))
if(length(idxs)) {
  print("Gene ID not found in expression data: ")
  str(gids[idxs])
}
dat <- exprData[na.omit(mm), ]
str(dat)

X1 <- t(dat[, classData==0])
X2 <- t(dat[, classData==1])
## DEGraph T2 test
res <- testOneGraph(gr, exprData, classData, verbose=TRUE, prop=0.2)
## T2 test (Hotelling)
rT2 <- T2.test(X1, X2)
str(rT2)
## Adaptive Neyman test
rAN <- AN.test(X1, X2, na.rm=TRUE)
str(rAN)
## Adaptive Neyman test from Fan and Lin (1998)
rAN <- AN.test(X1, X2, na.rm=TRUE)
str(rAN)
## Test from Bai and Saranadasa (1996)
rBS <- BS.test(X1, X2, na.rm=TRUE)
str(rBS)
## Hypergeometric test
pValues <- apply(exprData, 1, FUN=function(x) {
  tt <- t.test(x[classData==0], x[classData==1])
  tt$p.value
})
str(pValues)
names(pValues) <- rownames(exprData)
rHyper <- hyper.test(pValues, gids, thr=0.01)
str(rHyper)
**exprLoi2008**

**Format**

A vector of 255 elements which are either 0 (resistance to treatment) or 1 (sensitivity to treatment).

**Author(s)**

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

**Source**


**References**


**Examples**

```r
data("Loi2008_DEGraphVignette")
dim(classLoi2008)
head(classLoi2008)
```

**Description**

This data set gives gene expression data for a subset of 227 genes used in the DEGraph package vignette. This comes from the 15737 gene, 255 patient dataset of Loi et al. (2008) which was used to study resistance to tamoxifen treatment in hormone-dependent breast cancer.

**Usage**

`exprLoi2008`

**Format**

A matrix of 227 lines and 255 columns.

**Details**

The original data set corresponds to data processed by RMA and median-centered as available from the GSE6532 GEO archive: http://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE6532.

These data were summarized from the probe set level to the gene level as follows. The expression level of a gene was defined as the expression level of the probe set with largest alignment score among all probe sets mapping to this gene according to the annotation in GSE6532. When the largest alignment score was achieved by several probe sets, the median expression level of those probe sets was taken.
getConnectedComponentList

Author(s)
Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

Source

References

Examples

```r
data("Loi2008_DEGraphVignette")
dim(exprLoi2008)
head(exprLoi2008)
```

getConnectedComponentList

*Given a graph, returns a list of its connected components (which are also graph objects), ordered by decreasing number of nodes*

Description
Given a graph, returns a list of its connected components (which are also graph objects), ordered by decreasing number of nodes.

Usage

```
getConnectedComponentList(graph, verbose=FALSE)
```

Arguments

graph A graph object.

verbose If TRUE, extra information is output.

Value
A list containing a graph object for each connected component of the input graph, ordered by decreasing number of nodes

Author(s)
Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

See Also

connectedComp.
Examples

data("Loi2008_DEGraphVignette")
exprData <- exprLoi2008
rn <- rownames(exprData)

## Retrieve expression levels data for genes from one KEGG pathway
graph <- grListKEGG[[1]]
pname <- attr(graph, "label")
cat(toString(verbose), "Pathway name: ", pname)

sgraph <- getSignedGraph(graph, verbose=TRUE)
print(sgraph)

graphList <- getConnectedComponentList(graph, verbose=TRUE)
print(graphList)

getKEGGPathways

Builds a graph for each of the KEGG pathways

Description

Builds a graph for each of the KEGG pathways.

Usage

getKEGGPathways(path=NULL, rootPath="networkData/ftp.genome.jp/pub/kegg/xml/kgml", organism="hsa", metaTag=c("non-metabolic", "metabolic"), pattern=NULL, verbose=FALSE)

Arguments

path A character value, the local _full_ path of KGML data.
rootPath A character value, the local _root_ path of KGML data.
organism A character value specifying the organism whose pathways should be considered. Defaults to "hsa" (Homo Sapiens).
metaTag A character value, specifying the type of pathways to be considered ("metabolic" or "non-metabolic"). Defaults to "non-metabolic".
pattern An optional character value specifying a file name pattern to look for.
verbose If TRUE, extra information is output.

Details

If 'path' is supplied, KGML files in this directory are loaded. Otherwise, KGML files are assumed to be in <rootPath>/<metaTag>/<organisms>/<organism>, which mirrors the structure of the KEGG KGML file repository.

Value

A list containing a graph object for each KEGG pathway with at least one edge.

Author(s)

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit
getSignedGraph

Given a graph, builds a signed version of the adjacency matrix taking into account the type of interaction (e.g., activation or inhibition)

Description

Given a graph, builds a signed version of the adjacency matrix taking into account the type of interaction (e.g., activation or inhibition).

Usage

getSignedGraph(graph, positiveInteractionLabels=c("activation", "expression"), negativeInteractionLabels=c("inhibition", "repression"), verbose=FALSE)

Arguments

graph A graph object.
positiveInteractionLabels A character vector specifying which interaction labels correspond to positive interactions. Defaults to c("activation", "expression").
negativeInteractionLabels A character vector specifying which interaction labels correspond to negative interactions. Defaults to c("inhibition", "repression").
verbose If TRUE, extra information is output.
**Value**

This function returns a squared matrix whose (i,j) entry is:

- **0** if edges i and j are not connected
- **1** if edges i and j are connected by a positive interaction
- **-1** if edges i and j are connected by a negative interaction.

By construction, the absolute value of this matrix is the adjacency matrix of the graph. Edges which cannot interpreted as corresponding to a positive or a negative interaction are marked as not connected.

**Author(s)**

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

**Examples**

```r
data("Loi2008_DEGraphVignette")
exprData <- exprLoi2008
rn <- rownames(exprData)
## Retrieve expression levels data for genes from one KEGG pathway
graph <- grListKEGG[[1]]
pname <- attr(graph, "label")
cat(ffmpeg, "Pathway name: ", pname)

sgraph <- getSignedGraph(graph, verbose=TRUE)
print(sgraph)

graphList <- getConnectedComponentList(graph, verbose=TRUE)
print(graphList)
```

---

**graph.T2.test**

Performs the Hotelling T2 test in Fourier space

**Description**

Performs the Hotelling T2 test in Fourier space.

**Usage**

```r
graph.T2.test(X1, X2, G=NULL, lfa=NULL, ..., k=ncol(X1))
```

**Arguments**

- **X1** A n1 x p **numeric matrix**, observed data for class 1: p variables, n1 observations.
- **X2** A n2 x p **numeric matrix**, observed data for class 2: p variables, n2 observations.
- **G** An object of class **graphAM** or **graphNEL**, the graph to be used in the two-sample test.
1fA A list returned by \texttt{laplacianFromA()}, containing the Laplacian eigen vectors and eigen values

... Further arguments to be passed to \texttt{laplacianFromA}().

k A \texttt{numeric} value, number of Fourier components retained for the test.

Value

A \texttt{list} with class "htest", as returned by \texttt{T2.test}.

Author(s)

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

See Also

\texttt{T2.test graphAM}

Examples

library("rrcov")

## Some parameters
n1 <- n2 <- 20
nodes <- nedges <- 20
k <- 3
ncp <- 0.5
sigma <- diag(nnodes)/sqrt(nnodes)

## Build graph, decompose laplacian
G <- randomWAMGraph(nnodes=nnodes,nedges=nedges)
A <- G@adjMat
lfA <- laplacianFromA(A,ltype="unnormalized")
U <- lfA$U
l <- lfA$l

## Build two samples with smooth mean shift
X <- twoSampleFromGraph(n1,n2,shiftM2=ncp,sigma,U=U,k=k)

## Do hypothesis testing

t <- T2.test(X$X1,X$X2) # Raw T-square
print(t$p.value)
tu <- graph.T2.test(X$X1,X$X2,lfA=lfA,k=k) # Filtered T-squares
print(tu$p.value)

---

\textbf{grListKEGG} \hfill \textit{KEGG networks used in the DEGraph package vignette}

\textbf{Description}

This data set gives KEGG graph objects for two KEGG non-metabolic pathways ("Natural killer cell mediated cytotoxicity" and "Insulin signaling pathway").
hyper.test

Usage

grListKEGG

Format

A list of two elements.

Author(s)

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

Examples

library("Rgraphviz")

data("Loi2008_DEGraphVignette")
grListKEGG
plot(grListKEGG[[1]])

hyper.test

Perform an hypergeometric test of enrichment of a set of hypotheses in significant elements

Description

Performs an hypergeometric test of enrichment of a set of hypotheses in significant elements.

Usage

hyper.test(p.values, testSet, thr=0.001, universe=length(p.values), verbose=FALSE)

Arguments

- **p.values**: A named numeric vector giving the p-values of all tested elements.
- **testSet**: A character vector giving the ids of the elements in the tested set. Elements of `testSet` must have a match in `names(p.values)`.
- **thr**: A numeric value between 0 and 1 giving the threshold on p-values at which an element is declared to be significant.
- **universe**: An integer value giving the number of elements in the considered universe. Defaults to `length(p.values)`.
- **verbose**: If TRUE, extra information is output.

Value

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

- **statistic**: A numeric value, the test statistic.
- **p.value**: A numeric value, the corresponding p-value.
Examples

library("KEGGgraph")
## library("NCIgraph")
library("rrcov")

data("Loi2008_DEGraphVignette")
exprData <- exprLoi2008
classData <- classLoi2008
rn <- rownames(exprData)

## Retrieve expression levels data for genes from one KEGG pathway
gr <- grListKEGG[[1]]
gids <- translateKEGGID2GeneID(nodes(gr))
mm <- match(gids, rownames(exprData))

## Keep genes from the graph that are present in the expression data set
idxs <- which(!is.na(mm))
gr <- subGraph(nodes(gr)[idxs], gr)

idxs <- which(is.na(mm))
if(length(idxs)) {
  print("Gene ID not found in expression data: ")
  str(gids[idxs])
}
dat <- exprData[na.omit(mm), ]
str(dat)

X1 <- t(dat[, classData==0])
X2 <- t(dat[, classData==1])

## DEGraph T2 test
res <- testOneGraph(gr, exprData, classData, verbose=TRUE, prop=0.2)

## T2 test (Hotelling)
rT2 <- T2.test(X1, X2)
str(rT2)

## Adaptive Neyman test
rAN <- AN.test(X1, X2, na.rm=TRUE)
str(rAN)

## Adaptive Neyman test from Fan and Lin (1998)
rAN <- AN.test(X1, X2, na.rm=TRUE)
str(rAN)

## Test from Bai and Saranadasa (1996)
rBS <- BS.test(X1, X2, na.rm=TRUE)
str(rBS)
## Hypergeometric test

```r
pValues <- apply(exprData, 1, FUN=function(x) {
    tt <- t.test(x[classData==0], x[classData==1])
    tt$p.value
})
str(pValues)
names(pValues) <- rownames(exprData)
rHyper <- hyper.test(pValues, gids, thr=0.01)
str(rHyper)
```

### Description

Calculates the Laplacian associated to an adjacency matrix.

### Usage

```r
laplacianFromA(A, k=1, ltype=c("meanInfluence", "normalized", "unnormalized", "totalInfluence"))
```

### Arguments

- **A**: The adjacency matrix of the graph.
- **k**: ...
- **ltype**: A character value specifying the type of Laplacian to be calculated. Defaults to meanInfluence.

### Value

A list containing the following components:

- **U**: Eigenvectors of the graph Laplacian.
- **l**: Eigenvalues of the graph Laplacian
- **kIdx**: Multiplicity of '0' as eigenvalue.

### Author(s)

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

### Examples

```r
library("KEGGgraph")
library("rrcov")

## Create a random graph
graph <- randomWAMGraph(nnodes=5, nedges=7, verbose=TRUE)
plot(graph)

## Retrieve its adjacency matrix
A <- graph@adjMat
```
## write it to KGML file
grPathname <- "randomWAMGraph.xml"
writeAdjacencyMatrix2KGML(A, pathname=grPathname, verbose=TRUE, overwrite=TRUE)

## read it from file
gr <- parseKGML2Graph(grPathname)

## Two examples of Laplacians from the same graph
lapMI <- laplacianFromA(A, ltype="meanInfluence")
print(lapMI)

lapN <- laplacianFromA(A, ltype="normalized")
print(lapN)

U <- lapN$U
p <- nrow(A)
sigma <- diag(p)/sqrt(p)

X <- twoSampleFromGraph(100, 120, shiftM2=1, sigma, U=U, k=3)

## T2
t <- T2.test(X$X1, X$X2)
str(t)

tu <- graph.T2.test(X$X1, X$X2, lfA=lapMI, k=3)
str(tu)

### Description

Plots a graph with nodes colored according to a quantitative variable.

### Usage

```
plotValuedGraph(graph, values=NULL, nodeLabels=nodes(graph), qMax=0.95, colorPalette=heat.colors(10), adjustColorRange=FALSE, symmetrizeArrows=FALSE, height=1, lwd=1, cex=1, ..., verbose=FALSE)
```

### Arguments

- **graph**: A `graph` object.
- **values**: A named `vector` of `numeric` values according to which the graph nodes should be colored.
- **nodeLabels**: A `character vector` of the same length and in the same order as `nodes(graph)`: node labels to be displayed. Defaults to `nodes(graph)`.
- **qMax**: A `numeric` value, fraction of the data to be truncated in order to avoid outliers.
- **colorPalette**: A `character` vector, the set of colors to be used.
- **adjustColorRange**: A `logical` value. If TRUE, the color range is adjusted to the range of values of nodes actually present in the graph. Defaults to FALSE, i.e. the color range spans range(values) regardless of which nodes are present in the graph.
plotValuedGraph

symmetrizeArrows

A logical value. If TRUE, arrow tails are drawn as the corresponding arrow heads. Defaults to FALSE.

height

A numeric value, the (common) size of nodes.

lwd

A numeric value, the (common) width of edges.

cex

A numeric value, the relative size of the text for gene names.

... Further arguments to be passed to ‘edgeRenderInfo’ and ‘nodeRenderInfo’.

verbose If TRUE, extra information is output.

Value

A list containing the following components:

graph The ‘graph’ object as plotted.

breaks The break points in the supplied values (can be used for plotting a legend).

Author(s)

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

See Also

plotKEGGgraph plot()

Examples

library("Rgraphviz")
library("KEGGgraph")

## Retrieve expression levels data for genes from one KEGG pathway
graph <- grListKEGG[[1]]
pname <- attr(graph, "label")
print(pname)

## DEGraph T2 test
resList <- testOneGraph(graph, exprData, classData, verbose=TRUE, prop=0.2)

## Largest connected component
res <- resList[[1]]
gr <- res$graph

## individual t statistics
shift <- apply(exprData, 1, FUN=function(x) {
    tt <- t.test(x[classData==0], x[classData==1])
    tt$statistic
})
names(shift) <- translateGeneID2KEGGID(names(shift))

## color palette
if (require(marray)) {
  pal <- maPalette(low="red", high="green", mid="black", k=100)
} else {
  pal <- heat.colors(100)
}

## plot results
dn <- getDisplayName(gr, shortLabel=TRUE)
mm <- match(translateKEGGID2GeneID(nodes(gr)), rownames(annData))
dn <- annData[mm, "NCBI.gene.symbol"]
pvg <- plotValuedGraph(gr, values=shift, nodeLabels=dn, qMax=0.95, colorPalette=pal, height=40, lwd=1, verbose=TRUE)
text(3, pos=1, txt)

if (require(fields)) {
  image.plot(legend.only=TRUE, zlim=range(pvg$breaks), col=pal, legend.shrink=0.3, legend.width=0.8, legend.mar=3.3)
}

randomWAMGraph

Generates a random graph

Description

Generates a random graph.

Usage

randomWAMGraph(nnodes=5, nedges=nnodes, verbose=FALSE)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>nnodes</td>
<td>A numeric value, the desired number of nodes.</td>
</tr>
<tr>
<td>nedges</td>
<td>A numeric value, the desired number of edges.</td>
</tr>
<tr>
<td>verbose</td>
<td>If TRUE, extra information is output.</td>
</tr>
</tbody>
</table>

Value

An object of class graphAM.

Author(s)

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

See Also

graphAM.
**Examples**

```r
library("KEGGgraph")
library("rrcov")

## Create a random graph
graph <- randomWAMGraph(nnodes=5, nedges=7, verbose=TRUE)
plot(graph)

## Retrieve its adjacency matrix
A <- graph@adjMat

## write it to KGML file
grPathname <- "randomWAMGraph.xml"
writeAdjacencyMatrix2KGML(A, path=grPathname, verbose=TRUE, overwrite=TRUE)

## read it from file
gr <- parseKGML2Graph(grPathname)

## Two examples of Laplacians from the same graph
lapMI <- laplacianFromA(A, ltype="meanInfluence")
print(lapMI)

lapN <- laplacianFromA(A, ltype="normalized")
print(lapN)

U <- lapN$U
p <- nrow(A)
sigma <- diag(p)/sqrt(p)
X <- twoSampleFromGraph(100, 120, shiftM2=1, sigma, U=U, k=3)

## T2
T <- T2.test(X$X1, X$X2)
str(T)

tu <- graph.T2.test(X$X1, X$X2, lfA=lapMI, k=3)
str(tu)
```

---

**testOneConnectedComponent**

*Applies a series of two-sample tests to a connected graph using various statistics*

**Description**

Applies a series of two-sample tests to a connected graph using various statistics.

**Usage**

```r
testOneConnectedComponent(graph, data, classes, ..., prop=0.2, verbose=FALSE)
```
testOneConnectedComponent

Arguments

- **graph**
  - A graph object.
- **data**
  - A numeric matrix (size: number 'p' of genes x number 'n' of samples) of gene expression.
- **classes**
  - A character vector (length: 'n') of class assignments.
- **...**
  - Further arguments to be passed to laplacianFromA().
- **prop**
  - A numeric value, percentage of components retained for Fourier and PCA.
- **verbose**
  - If TRUE, extra information is output.

Details

This function performs the test, assuming that all genes in the graph are represented in the expression data set, in order not to have to modify the graph topology.

Interaction signs are used if available in the graph ('getSignedGraph' is not called here, in order not to have to modify the graph topology.).

The graph given as input has to have only one connex component. It can be retrieved from the output of getConnectedComponentList().

Value

A structured list containing the p-values of the tests, the graph object of the connected component and the number of retained Fourier dimensions.

Author(s)

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

See Also

testOneGraph() getConnectedComponentList()

Examples

```r
library("rrcov")

## Some parameters
n1 <- n2 <- 20
nnodes <- nedges <- 20
k <- 3
ncp <- 0.5
sigma <- diag(nnodes)/sqrt(nnodes)

## Build graph, decompose laplacian
G <- randomWAMGraph(nnodes=nnodes,nedges=nedges)
A <- G@adjMat
lfA <- laplacianFromA(A,ltype="unnormalized")
U <- lfA$U
l <- lfA$l

## Build two samples with smooth mean shift
X <- twoSampleFromGraph(n1,n2,shiftM2=ncp,sigma,U,k=k)
```
## Do hypothesis testing

t <- T2.test(X$X1,X$X2) # Raw T-square
print(t$p.value)

tu <- graph.T2.test(X$X1,X$X2,lfA=lfA,k=k) # Filtered T-squares
print(tu$p.value)

testOneGraph

Applies a serie of two-sample tests to each connected component of a graph using various statistics

Description

Applies a serie of two-sample tests to each connected component of a graph using various statistics.

Usage

testOneGraph(graph, data, classes, useInteractionSigns=TRUE, ..., verbose=FALSE)

Arguments

graph A graph object.
data A 'matrix' (size: number 'p' of genes x number 'n' of samples) of gene expression.
classes A 'vector' (length: 'n') of class assignments.
useInteractionSigns A logical value indicating whether the sign of interaction should be taken into account.
... Further arguments to be passed to testOneConnectedComponent.
verbose If TRUE, extra information is output.

Value

A structured list containing the p-values of the tests, the graph object of the connected component and the number of retained Fourier dimensions.

Author(s)

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

See Also

testOneConnectedComponent()
**Examples**

```r
data("Loi2008_DEGraphVignette")
exrData <- exprLoi2008
classData <- classLoi2008
anndata <- annLoi2008
rn <- rownames(exprData)

## Retrieve expression levels data for genes from one KEGG pathway
graph <- grListKEGG[[1]]
pname <- attr(graph, "label")
print(pname)

## DEGraph T2 test
resList <- testOneGraph(graph, exprData, classData, verbose=TRUE, prop=0.2)

## Largest connected component
res <- resList[[1]]
gr <- res$graph

## individual t statistics
shift <- apply(exprData, 1, FUN=function(x) {
  tt <- t.test(x[classData==0], x[classData==1])
  tt$statistic
})
names(shift) <- translateGeneID2KEGGID(names(shift))

## color palette
if (require(marray)) {
  pal <- maPalette(low="red", high="green", mid="black", k=100)
} else {
  pal <- heat.colors(100)
}

## plot results
dn <- getDisplayName(gr, shortLabel=TRUE)
mm <- match(translateKEGGID2GeneID(nodes(gr)), rownames(annData))
dn <- annData[mm, "NCBI.gene.symbol"]
pvg <- plotValuedGraph(gr, values=shift, nodeLabels=dn, qMax=0.95, colorPalette=pal, height=40, lwd=1, verbose=TRUE)

title(pname)
txt1 <- sprintf("p(T2)=%s", signif(res$p.value[1], 2))
txt2 <- sprintf("p(T2F[%s])=%s", res$k, signif(res$p.value[2]))
txt <- paste(txt1, txt2, sep="\n")
if (require(fields)) {
  image.plot(legend.only=TRUE, zlim=range(pvg$breaks), col=pal, legend.shrink=0.3, legend.width=0.8, legend.title=pname)
}
```

---

*testOneGraph*
twoSampleFromGraph

Given a basis (typically the eigenvectors of a graph Laplacian), builds two multivariate normal samples with mean shift located in the first elements of the basis

Description

Given a basis (typically the eigenvectors of a graph Laplacian), builds two multivariate normal samples with mean shift located in the first elements of the basis.

Usage

twoSampleFromGraph(n1=20, n2=n1, shiftM2=0, sigma, U, k=ceiling(ncol(U)/3))

Arguments

n1 An integer value specifying the number of points in the first sample.
n2 An integer value specifying the number of points in the second sample.
shiftM2 A numeric value giving the desired squared Mahalanobis norm of the mean shift between the two samples.
sigma A matrix giving the covariance structure of each sample.
U A matrix giving the desired basis.
k An integer value giving the number of basis elements in which the mean shift must be located.

Value

A list with named elements:

X1 The first sample in the original basis (before transformation by U).
X2 The second sample in the original basis (before transformation by U).
X1 The first sample in the specified basis (after transformation by U).
X2 The second sample in the specified basis (after transformation by U).
mu1 The population mean of F1
mu2 The population mean of F2
diff mu1 - mu2

Author(s)

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit
writeAdjacencyMatrix2KGML

*Exports an adjacency matrix into an XML file.*

### Usage

```r
writeAdjacencyMatrix2KGML(mat, pathname, nodePrefix="n", overwrite=FALSE, ..., verbose=FALSE)
```

### Arguments

- **mat**: A *matrix*, interpreted as the adjacency matrix of a graph.
- **pathname**: The name of the file to be written.
- **nodePrefix**: A prefix to be added to the node names in the KGML file.
- **overwrite**: If `TRUE`, overwrite the file if it already exists.
- **...**: Additional arguments passed to `write.csv`.
- **verbose**: If `TRUE`, print progress messages.

### Description

`writeAdjacencyMatrix2KGML` writes an adjacency matrix into a KGML file.

### Examples

```r
library("KEGGgraph")
library("rrcov")

## Create a random graph
graph <- randomWAMGraph(nnodes=5, nedges=7, verbose=TRUE)
plot(graph)

## Retrieve its adjacency matrix
A <- graph@adjMat

## Export it to KGML file
grPathname <- "randomWAMGraph.xml"
writeAdjacencyMatrix2KGML(A, pathname=grPathname, verbose=TRUE, overwrite=TRUE)

## Read it back in
gr <- readKGML2Graph(grPathname)

## Two examples of Laplacians from the same graph
lapMI <- laplacianFromA(A, ltype="meanInfluence")
print(lapMI)

lapN <- laplacianFromA(A, ltype="normalized")
print(lapN)

U <- lapN$U
p <- nrow(A)
sigma <- diag(p)/sqrt(p)

X <- twoSampleFromGraph(100, 120, shiftM2=1, sigma, U=U, k=3)

## T2

str(t)
str(tu)
```

---

**writeAdjacencyMatrix2KGML**

*Exports an adjacency matrix into an XML file.*

### Description

Exports an adjacency matrix into an XML file.

### Usage

```r
writeAdjacencyMatrix2KGML(mat, pathname, nodePrefix="n", overwrite=FALSE, ..., verbose=FALSE)
```

### Arguments

- **mat**: A *matrix*, interpreted as the adjacency matrix of a graph.
- **pathname**: The name of the file to be written.
- **nodePrefix**: A prefix to be added to the node names in the KGML file.
- **overwrite**: If `TRUE`, overwrite the file if it already exists.
- **...**: Additional arguments passed to `write.csv`.
- **verbose**: If `TRUE`, print progress messages.
writeAdjacencyMatrix2KGML

pathname The full path name of the XML file to be written.

nodePrefix A character value giving the prefix to which the node index in ’mat’ will be appended.

overwrite If TRUE and file already exists, overwrite it.

... Further arguments to be passed to plotKEGGgraph.

verbose If TRUE, extra information is output.

Value

None.

Author(s)

Laurent Jacob, Pierre Neuvial and Sandrine Dudoit

See Also

parseKGML2Graph

Examples

library("KEGGgraph")
library("rrcov")

## Create a random graph
graph <- randomWAMGraph(nnodes=5, nedges=7, verbose=TRUE)
plot(graph)

## Retrieve its adjacency matrix
A <- graph@adjMat

## write it to KGML file
grPathname <- "randomWAMGraph.xml"
writeAdjacencyMatrix2KGML(A, pathname=grPathname, verbose=TRUE, overwrite=TRUE)

## read it from file
gr <- parseKGML2Graph(grPathname)

## Two examples of Laplacians from the same graph
lapMI <- laplacianFromA(A, ltype="meanInfluence")
print(lapMI)

lapN <- laplacianFromA(A, ltype="normalized")
print(lapN)

U <- lapN$U
p <- nrow(A)
sigma <- diag(p)/sqrt(p)

X <- twoSampleFromGraph(100, 120, shiftM2=1, sigma, U=U, k=3)

## T2
t <- T2.test(X$X1,X$X2)
str(t)
tu <- graph.T2.test(X$X1, X$X2, lfA=lapMI, k=3)
str(tu)
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