

# Package ‘topGO’

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**Type** Package

**Title** Enrichment Analysis for Gene Ontology

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**Description** topGO package provides tools for testing GO terms while accounting for the topology of the GO graph. Different test statistics and different methods for eliminating local similarities and dependencies between GO terms can be implemented and applied.

**License** LGPL

**Depends** R (>= 2.10.0), methods, BiocGenerics (>= 0.13.6), graph (>= 1.14.0), Biobase (>= 2.0.0), GO.db (>= 2.3.0), AnnotationDbi (>= 1.7.19), SparseM (>= 0.73)

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| topGO-package | <i>Enrichment analysis for Gene Ontology</i> |
|---------------|--|

---

### Description

topGO package provides tools for testing GO terms while accounting for the topology of the GO graph. Different test statistics and different methods for eliminating local similarities and dependencies between GO terms can be implemented and applied.

### Details

|          |                           |
|----------|---------------------------|
| Package: | topGO                     |
| Type:    | Package                   |
| Version: | 1.0                       |
| Date:    | 2006-10-02                |
| License: | What license is it under? |

TODO: An overview of how to use the package, including the most important functions

### Author(s)

Adrian Alexa, J"org Rahnenf"uhrer

Maintainer: Adrian Alexa

### References

Alexa A., Rahnenf"uhrer J., Lengauer T., Improved scoring of functional groups from gene expression data by decorrelating GO graph structure, *Bioinformatics* 22(13): 1600-1607, 2006

**See Also**

[topGOdata-class](#), [groupStats-class](#), [getSigGroups-methods](#)

---

annFUN

*Functions which map gene identifiers to GO terms*


---

**Description**

These functions are used to compile a list of GO terms such that each element in the list is a character vector containing all the gene identifiers that are mapped to the respective GO term.

**Usage**

```
annFUN.db(whichOnto, feasibleGenes = NULL, affyLib)
annFUN.org(whichOnto, feasibleGenes = NULL, mapping, ID = "entrez")
annFUN(whichOnto, feasibleGenes = NULL, affyLib)
annFUN.gene2GO(whichOnto, feasibleGenes = NULL, gene2GO)
annFUN.GO2genes(whichOnto, feasibleGenes = NULL, GO2genes)
annFUN.file(whichOnto, feasibleGenes = NULL, file, ...)

readMappings(file, sep = "\t", IDsep = ",")
inverseList(l)
```

**Arguments**

|               |  |
|---------------|--|
| whichOnto     | character string specifying one of the three GO ontologies, namely: "BP", "MF", "CC"   |
| feasibleGenes | character vector containing a subset of gene identifiers. Only these genes will be used to annotate GO terms. Default value is NULL which means that there are no genes filtered.                            |
| affyLib       | character string containing the name of the Bioconductor annotation package for a specific microarray chip.  |
| gene2GO       | named list of character vectors. The list names are genes identifiers. For each gene the character vector contains the GO identifiers it maps to. Only the most specific annotations are required.           |
| GO2genes      | named list of character vectors. The list names are GO identifiers. For each GO the character vector contains the genes identifiers which are mapped to it. Only the most specific annotations are required. |
| mapping       | character string specifying the name of the Bioconductor package containing the gene mappings for a specific organism. For example: mapping = "org.Hs.eg.db".  |
| ID            | character string specifying the gene identifier to use. Currently only the following identifiers can be used: c("entrez", "genbank", "alias", "ensembl", "symbol", "genename", "unigene")                    |
| file          | character string specifying the file containing the annotations.   |
| ...           | other parameters   |
| sep           | the character used to separate the columns in the CSV file   |
| IDsep         | the character used to separate the annotated entities  |
| l             | a list containing mappings   |

## Details

All these function restrict the GO terms to the ones belonging to the specified ontology and to the genes listed in the `feasibleGenes` attribute (if not empty).

The function `annFUN.db` uses the mappings provided in the Bioconductor annotation data packages. For example, if the Affymetrix `hgu133a` chip it is used, then the user should set `affyLib = "hgu133a.db"`.

The functions `annFUN.gene2GO` and `annFUN.GO2genes` are used when the user provide his own annotations either as a gene-to-GOs mapping, either as a GO-to-genes mapping.

The `annFUN.org` function is using the mappings from the "org.XX.XX" annotation packages. The function supports different gene identifiers.

The `annFUN.file` function will read the annotations of the type `gene2GO` or `GO2genes` from a text file.

## Value

A `named(GO identifiers)` list of character vectors.

## Author(s)

Adrian Alexa

## See Also

[topGOdata-class](#)

## Examples

```
library(hgu133a.db)
set.seed(111)

## generate a gene list and the GO annotations
selGenes <- sample(ls(hgu133aGO), 50)
gene2GO <- lapply(mget(selGenes, envir = hgu133aGO), names)
gene2GO[sapply(gene2GO, is.null)] <- NA

## the annotation for the first three genes
gene2GO[1:3]

## inverting the annotations
G2g <- inverseList(gene2GO)

## inverting the annotations and selecting an ontology
go2genes <- annFUN.gene2GO(whichOnto = "CC", gene2GO = gene2GO)

## generate a GO list with the genes annotations
selGO <- sample(ls(hgu133aGO2PROBE), 30)
GO2gene <- lapply(mget(selGO, envir = hgu133aGO2PROBE), as.character)

GO2gene[1:3]

## select only the GO terms for a specific ontology
go2gene <- annFUN.GO2genes(whichOnto = "CC", GO2gene = GO2gene)
```

```
#####
## Using the org.XX.xx.db annotations
#####

## GO to Symbol mappings (only the BP ontology is used)
xx <- annFUN.org("BP", mapping = "org.Hs.eg.db", ID = "symbol")
head(xx)

## Not run:

allGenes <- unique(unlist(xx))
myInterestedGenes <- sample(allGenes, 500)
geneList <- factor(as.integer(allGenes)
names(geneList) <- allGenes

GOdata <- new("topGOdata",
  ontology = "BP",
  allGenes = geneList,
  nodeSize = 5,
  annot = annFUN.org,
  mapping = "org.Hs.eg.db",
  ID = "symbol")

## End(Not run)
```

---

classicCount-class      *Class "classicCount"*

---

## Description

This class that extends the virtual class "groupStats" by adding a slot representing the significant members.

## Details

This class is used for test statistic based on counts, like Fisher's exact test

## Objects from the Class

Objects can be created by calls of the form `new("classicCount", testStatistic = "function", name = "character", allMembers = "character", groupMembers = "character", sigMembers = "character")`.

## Slots

significant: Object of class "integer" ~~  
name: Object of class "character" ~~  
allMembers: Object of class "character" ~~  
members: Object of class "character" ~~  
testStatistic: Object of class "function" ~~

**Extends**

Class "groupStats", directly.

**Methods**

**contTable** signature(object = "classicCount"): ...  
**initialize** signature(.Object = "classicCount"): ...  
**numSigAll** signature(object = "classicCount"): ...  
**numSigMembers** signature(object = "classicCount"): ...  
**sigAllMembers** signature(object = "classicCount"): ...  
**sigMembers<-** signature(object = "classicCount"): ...  
**sigMembers** signature(object = "classicCount"): ...

**Author(s)**

Adrian Alexa

**See Also**

[classicScore-class](#), [groupStats-class](#), [getSigGroups-methods](#)

**Examples**

```
##---- Should be DIRECTLY executable !! ----
```

---

classicExpr-class      *Class "classicExpr"*

---

**Description**

This class that extends the virtual class "groupStats" by adding two slots for accomodating gene expression data.

**Objects from the Class**

Objects can be created by calls of the form `new("classicExpr", testStatistic, name, groupMembers, exprDat, pType, ...)`.

**Slots**

**eData:** Object of class "environment" ~~  
**pType:** Object of class "factor" ~~  
**name:** Object of class "character" ~~  
**allMembers:** Object of class "character" ~~  
**members:** Object of class "character" ~~  
**testStatistic:** Object of class "function" ~~  
**testStatPar:** Object of class "list" ~~

**Extends**

Class "[groupStats](#)", directly.

**Methods**

**allMembers**<- signature(object = "classicExpr"): ...  
**emptyExpr** signature(object = "classicExpr"): ...  
**getSigGroups** signature(object = "topGOdata", test.stat = "classicExpr"): ...  
**GOglobalTest** signature(object = "classicExpr"): ...  
**initialize** signature(.Object = "classicExpr"): ...  
**membersExpr** signature(object = "classicExpr"): ...  
**pType**<- signature(object = "classicExpr"): ...  
**pType** signature(object = "classicExpr"): ...

**Author(s)**

Adrian Alexa

**See Also**

[classicScore-class](#), [groupStats-class](#), [getSigGroups-methods](#)

**Examples**

```
showClass("classicExpr")
```

---

|                    |                             |
|--------------------|-----------------------------|
| classicScore-class | <i>Class "classicScore"</i> |
|--------------------|-----------------------------|

---

**Description**

A class that extends the virtual class "[groupStats](#)" by adding a slot representing the score of each gene. It is used for tests like Kolmogorov-Smirnov test.

**Objects from the Class**

Objects can be created by calls of the form `new("classicScore", testStatistic, name, allMembers, groupMembers, score, decreasing)`.

**Slots**

**score:** Object of class "numeric" ~~  
**name:** Object of class "character" ~~  
**allMembers:** Object of class "character" ~~  
**members:** Object of class "character" ~~  
**testStatistic:** Object of class "function" ~~  
**scoreOrder:** Object of class "character" ~~  
**testStatPar:** Object of class "ANY" ~~

**Extends**

Class "groupStats", directly.

**Methods**

**allScore** Method to obtain the score of all members.

**scoreOrder** Returns TRUE if the score should be ordered increasing, FALSE otherwise.

**membersScore** signature(object = "classicScore"): ...

**rankMembers** signature(object = "classicScore"): ...

**score<-** signature(object = "classicScore"): ...

**Author(s)**

Adrian Alexa

**See Also**

[classicCount-class](#), [groupStats-class](#), [getSigGroups-methods](#)

**Examples**

```
## define the type of test you want to use
test.stat <- new("classicScore", testStatistic = GOKSTest, name = "KS tests")
```

---

Determines the levels of a Directed Acyclic Graph (DAG)

*Utility functions to work with Directed Acyclic Graphs (DAG)*

---

**Description**

Basic functions to work with DAGs

**Usage**

```
buildLevels(dag, root = NULL, leafs2root = TRUE)
getNoOfLevels(graphLevels)
getGraphRoot(dag, leafs2root = TRUE)
reverseArch(dirGraph, useAlgo = "sparse", useWeights = TRUE)
```

**Arguments**

|             |   |
|-------------|---|
| dag         | A graphNEL object.  |
| root        | A character vector specifying the root(s) of the DAG. If not specified the root node is automatically computed. |
| leafs2root  | The leafs2root parameter tells if the graph has edges directed from the leaves to the root, or vice-versa       |
| graphLevels | An object of type list, returned by the buildLevels function.   |
| dirGraph    | A graphNEL object containing a directed graph.  |



|            |  |
|------------|--|
| useAlgo    | A character string specifying one of the following options c("sparse", "normal"). By default, useAlgo = "sparse", a sparse matrix object is used to transpose the adjacency matrix. Otherwise a standard R matrix is used. |
| useWeights | If weights should be used (if useAlgo = "normal" then the weights are used anyway)   |

### Details

buildLevels function determines the levels of a Directed Acyclic Graph (DAG). The level of a node is defined as the longest path from the node to the root. The function takes a named list containing various information about each node's level. The root has level 1.

getNoOfLevels - a convenient function to extract the number of levels from the object returned by buildLevels

getGraphRoot finds the root(s) of the DAG

reverseArch - simple function to invert the direction of edges in a DAG. The returned graph is of class graphNEL. It can use either simple matrices or sparse matrices (SparseM library)

### Value

buildLevels returns a list containing:

|             |   |
|-------------|---|
| level2nodes | Environment where the key is the level number with the value being the nodes on that level.                 |
| nodes2level | Environment where the key is the node label (the GO ID) and the value is the level on which that node lies. |
| noOfLevels  | The number of levels  |
| noOfNodes   | The number of nodes   |

An object of class `graphNEL-class` is returned.

### Author(s)

Adrian Alexa

### See Also

[topGOdata-class](#), [inducedGraph](#)

### Examples

```
##---- Should be DIRECTLY executable !! ----
##-- ==> Define data, use random,
##-- or do help(data=index) for the standard data sets.
```

---

diagnostic-methods      *Diagnostic functions for topGOdata and topGOresult objects.*

---

### Description

The GenTable function generates a summary of the results of the enrichment analysis.

The showGroupDensity function plots the distributions of the gene' scores/ranks inside a GO term.

The printGenes function shows a short summary of the top genes annotated to the specified GO terms.

### Usage

```
GenTable(object, ...)
```

```
showGroupDensity(object, whichGO, ranks = FALSE, rm.one = TRUE)
```

```
printGenes(object, whichTerms, file, ...)
```

### Arguments

|            |  |
|------------|--|
| object     | an object of class topGOdata.  |
| whichGO    | the GO terms for which the plot should be generated.   |
| ranks      | if ranks should be used instead of scores.   |
| rm.one     | the p-values which are 1 are removed.  |
| whichTerms | character vector listing the GO terms for which the summary should be printed.   |
| file       | character string specifying the file in which the results should be printed.   |
| ...        | Extra arguments for GenTable can be:<br>... one or more objects of class topGOresult.<br>orderBy if more than one topGOresult object is given then orderBy gives the index of which scores will be used to order the resulting table. Can be an integer index or a character vector given the name of the topGOresult object.<br>ranksOf same as orderBy argument except that this parameter shows the relative ranks of the specified result.<br>topNodes the number of top GO terms to be included in the table.<br>numChar the GO term definition will be truncated such that only the first numChar characters are shown.<br>Extra arguments for printGenes can be:<br>chip character string containing the name of the Bioconductor annotation package for a microarray chip.<br>numChar the gene description is trimmed such that it has numChar characters.<br>simplify logical variable affecting how the results are returned.<br>geneCutOff the maximal number of genes shown for each term.<br>pvalCutOff only the genes with a p-value less than pvalCutOff are shown.<br>oneFile if TRUE then a file for each GO term is generated. |

**Details**

GenTable is an easy to use function for summarising the most significant GO terms and the corresponding p-values. The function dispatches for topGOdata and topGOresult objects, and it can take an arbitrary number of the later, making comparison between various results easier.

Note: One needs to type the complete attribute names (the exact name) of this function, like: topNodes = 5, rankOf = "resultFis", etc. This being the price paid for flexibility of specifying different number of topGOdata objects.

The showGroupDensity function analyse the distribution of the gene-wise scores for a specified GO term. The function will show the distribution of the genes in a GO term compared with the complementary set, using a lattice plot.

printGenes The function will generate a table with all the probes annotated to the specified GO term. Various type of identifiers, the gene name and the gene-wise statistics are provided in the table.

One or more GO identifiers can be given to the function using the whichTerms argument. When more than one GO is specified, the function returns a list of data.frames, otherwise only one data.frame is returned.

The function has a argument file which, when specified, will save the results into a file using the CSV format.

For the moment the function will work only when the chip used has an annotation package available in Bioconductor. It will not work with other type of custom annotations.

**Value**

A data.frame or a list of data.fames.

**Author(s)**

Adrian Alexa

**See Also**

[groupStats-class](#), [getSigGroups-methods](#)

**Examples**

```
data(GOdata)

#####
## GenTable
#####

## load two topGOresult sample objects: resultFisher and resultKS
data(results.tGO)

## generate the result of Fisher's exact test
sig.tab <- GenTable(GOdata, Fis = resultFisher, topNodes = 20)

## results of both test
sig.tab <- GenTable(GOdata, resultFisher, resultKS, topNodes = 20)

## results of both test with specified names
```

```

sig.tab <- GenTable(GOdata, Fis = resultFisher, KS = resultKS, topNodes = 20)

## results of both test with specified names and specified ordering
sig.tab <- GenTable(GOdata, Fis = resultFisher, KS = resultKS, orderBy = "KS", ranksOf = "Fis", topNodes = 20)

#####
## showGroupDensity
#####

goID <- "GO:0006091"
print(showGroupDensity(GOdata, goID, ranks = TRUE))
print(showGroupDensity(GOdata, goID, ranks = FALSE, rm.one = FALSE))

#####
## printGenes
#####

## Not run:
library(hgu95av2.db)
goID <- "GO:0006629"

gt <- printGenes(GOdata, whichTerms = goID, chip = "hgu95av2.db", numChar = 40)

goIDs <- c("GO:0006629", "GO:0007076")
gt <- printGenes(GOdata, whichTerms = goIDs, chip = "hgu95av2.db", pvalCutOff = 0.01)

gt[goIDs[1]]

## End(Not run)

```

---

elimCount-class            *Classes "elimCount" and "weight01Count"*

---

## Description

Classes that extend the "classicCount" class by adding a slot representing the members that need to be removed.

## Objects from the Class

Objects can be created by calls of the form `new("elimCount", testStatistic, name, allMembers, groupMembers, sigMembers, elim, cutOff, ...)`.

## Slots

elim: Object of class "integer" ~~  
cutOff: Object of class "numeric" ~~  
significant: Object of class "integer" ~~  
name: Object of class "character" ~~  
allMembers: Object of class "character" ~~

members: Object of class "character" ~~  
 testStatistic: Object of class "function" ~~  
 testStatPar: Object of class "list" ~~

### Extends

Class "[classicCount](#)", directly. Class "[groupStats](#)", by class "classicCount", distance 2.

### Methods

No methods defined with class "elimCount" in the signature.

### Author(s)

Adrian Alexa

### See Also

[classicScore-class](#), [groupStats-class](#), [getSigGroups-methods](#)

---

|                |                         |
|----------------|-------------------------|
| elimExpr-class | <i>Class "elimExpr"</i> |
|----------------|-------------------------|

---

### Description

Classes that extend the "classicExpr" class by adding a slot representing the members that need to be removed.

### Details

TODO: Some details here.....

### Objects from the Class

Objects can be created by calls of the form `new("elimExpr", testStatistic, name, groupMembers, exprDat, pType, elim, cutOff, ...)`. ~~ describe objects here ~~

### Slots

cutOff: Object of class "numeric" ~~  
 elim: Object of class "integer" ~~  
 eData: Object of class "environment" ~~  
 pType: Object of class "factor" ~~  
 name: Object of class "character" ~~  
 allMembers: Object of class "character" ~~  
 members: Object of class "character" ~~  
 testStatistic: Object of class "function" ~~  
 testStatPar: Object of class "list" ~~

**Extends**

Class "[weight01Expr](#)", directly. Class "[classicExpr](#)", by class "weight01Expr", distance 2.  
Class "[groupStats](#)", by class "weight01Expr", distance 3.

**Methods**

**cutOff**<- signature(object = "elimExpr"): ...  
**cutOff** signature(object = "elimExpr"): ...  
**getSigGroups** signature(object = "topGOdata", test.stat = "elimExpr"): ...  
**initialize** signature(.Object = "elimExpr"): ...

**Author(s)**

Adrian Alexa

**See Also**

[classicScore-class](#), [groupStats-class](#), [getSigGroups-methods](#)

**Examples**

```
showClass("elimExpr")
```

---

|                 |  |
|-----------------|--|
| elimScore-class | <i>Classes "elimScore" and "weight01Score"</i> |
|-----------------|--|

---

**Description**

Classes that extend the "classicScore" class by adding a slot representing the members that need to be removed.

**Details**

TODO:

**Objects from the Class**

Objects can be created by calls of the form `new("elimScore", testStatistic, name, allMembers, groupMembers, score, alternative, elim, cutOff, ...)`. ~~ describe objects here ~~

**Slots**

**elim**: Object of class "integer" ~~  
**cutOff**: Object of class "numeric" ~~  
**score**: Object of class "numeric" ~~  
**.alternative**: Object of class "logical" ~~  
**name**: Object of class "character" ~~  
**allMembers**: Object of class "character" ~~  
**members**: Object of class "character" ~~  
**testStatistic**: Object of class "function" ~~  
**testStatPar**: Object of class "list" ~~

**Extends**

Class "[classicScore](#)", directly. Class "[groupStats](#)", by class "classicScore", distance 2.

**Methods**

No methods defined with class "elimScore" in the signature.

**Author(s)**

Adrian Alexa

**See Also**

[classicScore-class](#), [groupStats-class](#), [getSigGroups-methods](#)

**Examples**

```
##---- Should be DIRECTLY executable !! ----
```

---

Gene set tests statistics

*Gene set tests statistics*

---

**Description**

Methods which implement and run a group test statistic for a class inheriting from `groupStats` class. See Details section for a description of each method.

**Usage**

```
GOFisherTest(object)
GOKSTest(object)
GOTest(object)
GOGlobalTest(object)
GOSumTest(object)
GOKSTiesTest(object)
```

**Arguments**

`object`            An object of class `groupStats` or decedent class.

**Details**

`GOFisherTest`: implements Fischer's exact test (based on contingency table) for `groupStats` objects dealing with "counts".

`GOKSTest`: implements the Kolmogorov-Smirnov test for `groupStats` objects dealing with gene "scores". This test uses the `ks.test` function and does not implement the running-sum-statistic test based on permutations.

`GOTest`: implements the t-test for `groupStats` objects dealing with gene "scores". It should be used when the gene scores are t-statistics or any other score following a normal distribution.

`GOGlobalTest`: implement Goeman's `globaltest`.

**Value**

All these methods return the p-value computed by the respective test statistic.

**Author(s)**

Adrian Alexa

**See Also**

[groupStats-class](#), [getSigGroups-methods](#)

---

geneList

*A toy example of a list of gene identifiers and the respective p-values*

---

**Description**

The `geneList` data is compiled from a differential expression analysis of the ALL dataset. It contains just a small number of genes with the correspondent p-values. The information on where to find the GO annotations is stored in the ALL object.

The `topDiffGenes` function included in this dataset will select the differentially expressed genes, at 0.01 significance level, from `geneList`.

**Usage**

```
data(geneList)
```

**Source**

Generated using the ALL gene expression data. See the "scripts" directory.

**Examples**

```
data(geneList)

## print the object
head(geneList)
length(geneList)

## the number of genes with a p-value less than 0.01
sum(topDiffGenes(geneList))
```



---

|            |   |
|------------|---|
| getPvalues | <i>Convenient function to compute p-values from a gene expression matrix.</i> |
|------------|---|

---

### Description

Wrapping function of "mt.teststat", for computing p-values of a gene expression matrix.

### Usage

```
getPvalues(edata, classlabel, test = "t", alternative = c("greater", "two.sided", "less")[1],
genesID = NULL, correction = c("none", "Bonferroni", "Holm", "Hochberg", "SidakSS", "SidakSD",
"BH", "BY")[8])
```

### Arguments

|             |                                       |
|-------------|---------------------------------------|
| edata       | Gene expression matrix.               |
| classlabel  | The phenotype of the data             |
| test        | Which test statistic to use           |
| alternative | The alternative of the test statistic |
| genesID     | if a subset of genes is provided      |
| correction  | Multiple testing correction procedure |

### Value

An named numeric vector of p-values.

### Author(s)

Adrian Alexa

### See Also

[GOKSTest](#), [groupStats-class](#), [getSigGroups-methods](#)

### Examples

```
library(ALL)
data(ALL)

## discriminate B-cell from T-cell
classLabel <- as.integer(sapply(ALL$BT, function(x) return(substr(x, 1, 1) == 'T'))))

## Differentially expressed genes
geneList <- getPvalues(exprs(ALL), classlabel = classLabel,
                      alternative = "greater", correction = "BY")

hist(geneList, 50)
```

---

`getSigGroups`*Interfaces for running the enrichment tests*

---

**Description**

These function are used for dispatching the specific algorithm for a given topGOdata object and a test statistic.

**Usage**

```
getSigGroups(object, test.stat, ...)  
runTest(object, algorithm, statistic, ...)  
whichAlgorithms()  
whichTests()
```

**Arguments**

|                        |  |
|------------------------|--|
| <code>object</code>    | An object of class topGOdata This object contains all data necessary for running the test. |
| <code>test.stat</code> | An object of class groupStats. This object defines the test statistic.                     |
| <code>algorithm</code> | Character string specifying which algorithm to use.  |
| <code>statistic</code> | Character string specifying which test to use.   |
| <code>...</code>       | Other parameters. In the case of runTest they are used for defining the test statistic     |

**Details**

The runTest function can be used only with a predefined set of test statistics and algorithms. The algorithms and the statistical tests which are accessible via the runTest function are shown by the whichAlgorithms() and whichTests() functions.

The runTest function is a warping of the getSigGroups and the initialisation of a groupStats object functions.

...

**Value**

An object of class topGOresult.

**Author(s)**

Adrian Alexa

**See Also**

[topGOdata-class](#), [groupStats-class](#), [topGOresult-class](#)

**Examples**

```

## load a sample topGOdata object
data(GOdata)
GOdata

#####
## getSigGroups interface
#####

## define a test statistic
test.stat <- new("classicCount", testStatistic = GOFisherTest, name = "Fisher test")
## perform the test
resultFis <- getSigGroups(GOdata, test.stat)
resultFis

#####
## runTest interface
#####

## Enrichment analysis by using the "classic" method and Fisher's exact test
resultFis <- runTest(GOdata, algorithm = "classic", statistic = "fisher")
resultFis

## weight01 is the default algorithm
weight01.fisher <- runTest(GOdata, statistic = "fisher")
weight01.fisher

## not all combinations are possible!
# weight.ks <- runTest(GOdata, algorithm = "weight", statistic = "t")

```

---

GOdata

*Sample topGOdata and topGOresult objects*


---

**Description**

The GOdata contains an instance of a topGOdata object. It can be used to run an enrichment analysis directly.

The resultFisher contains the results of an enrichment analysis.

**Usage**

```
data(GOdata)
```

**Source**

Generated using the ALL gene expression data. See [topGOdata-class](#) for code examples on how-to generate such an object.

**Examples**

```
data(GOdata)

## print the object
GOdata

data(results.tGO)

## print the object
resultFisher
```

---

|              |   |
|--------------|---|
| groupGOTerms | <i>Grouping of GO terms into the three ontologies</i> |
|--------------|---|

---

**Description**

This function split the GOTERM environment into three different ontologies. The newly created environments contain each only the terms from one of the following ontologies 'BP', 'CC', 'MF'

**Usage**

```
groupGOTerms(when)
```

**Arguments**

when            The the environment where you want to bind the results.

**Value**

The function returns NULL.

**Author(s)**

Adrian Alexa

**See Also**

[topGOdata-class](#), [GOTERM](#)

**Examples**

```
groupGOTerms()
```

---

groupStats-class      *Class "groupStats"*

---

### Description

A virtual class containing basic gene set information: the gene universe, the member of the current group, the test statistic defined for this group, etc.

### Objects from the Class

A virtual Class: No objects may be created from it.

### Slots

name: Object of class "character" ~~  
 allMembers: Object of class "character" ~~  
 members: Object of class "character" ~~  
 testStatistic: Object of class "function" ~~  
 testStatPar: Object of class "ANY" ~~

### Methods

**allMembers**<- signature(object = "groupStats"): ...  
**allMembers** signature(object = "groupStats"): ...  
**initialize** signature(.Object = "groupStats"): ...  
**members**<- signature(object = "groupStats"): ...  
**members** signature(object = "groupStats"): ...  
**Name**<- signature(object = "groupStats"): ...  
**Name** signature(object = "groupStats"): ...  
**numAllMembers** signature(object = "groupStats"): ...  
**numMembers** signature(object = "groupStats"): ...  
**runTest** signature(object = "groupStats"): ...  
**testStatistic** signature(object = "groupStats"): ...

### Author(s)

Adrian Alexa

### See Also

[classicCount-class](#), [getSigGroups-methods](#)

---

|              |  |
|--------------|--|
| inducedGraph | <i>The subgraph induced by a set of nodes.</i> |
|--------------|--|

---

### Description

Given a set of nodes (GO terms) this function is returning the subgraph containing these nodes and their ancestors.

### Usage

```
inducedGraph(dag, startNodes)
nodesInInducedGraph(dag, startNodes)
```

### Arguments

|            |   |
|------------|---|
| dag        | An object of class <code>graphNEL</code> containing a directed graph. |
| startNodes | A character vector giving the starting nodes.                         |

### Value

An object of class `graphNEL-class` is returned.

### Author(s)

Adrian Alexa

### See Also

[topGOdata-class](#), [reverseArch](#),

### Examples

```
data(GOdata)

## the GO graph
g <- graph(GOdata)
g

## select 10 random nodes
sn <- sample(nodes(g), 10)

## the subgraph induced by these nodes
sg <- inducedGraph(g, sn)
sg
```

---

parentChild-class      *Classes "parentChild" and "pC"*

---

### Description

Classes that extend the "classicCount" class by adding support for the parent-child test.

### Objects from the Class

Objects can be created by calls of the form `new("parentChild", testStatistic, name, groupMembers, parents, sigMembers, joinFun, ...)`.

### Slots

splitIndex: Object of class "integer" ~~  
 joinFun: Object of class "character" ~~  
 significant: Object of class "integer" ~~  
 name: Object of class "character" ~~  
 allMembers: Object of class "character" ~~  
 members: Object of class "character" ~~  
 testStatistic: Object of class "function" ~~  
 testStatPar: Object of class "list" ~~

### Extends

Class "`classicCount`", directly. Class "`groupStats`", by class "`classicCount`", distance 2.

### Methods

**allMembers**<- signature(object = "parentChild"): ...  
**allMembers** signature(object = "parentChild"): ...  
**allParents** signature(object = "parentChild"): ...  
**getSigGroups** signature(object = "topGOdata", test.stat = "parentChild"): ...  
**initialize** signature(.Object = "parentChild"): ...  
**joinFun** signature(object = "parentChild"): ...  
**numAllMembers** signature(object = "parentChild"): ...  
**numSigAll** signature(object = "parentChild"): ...  
**sigAllMembers** signature(object = "parentChild"): ...  
**sigMembers**<- signature(object = "parentChild"): ...  
**updateGroup** signature(object = "parentChild", name = "missing", members = "character"): ...  
 ...

### Author(s)

Adrian Alexa

**See Also**

[classicCount-class](#), [groupStats-class](#), [getSigGroups-methods](#)

**Examples**

```
showClass("parentChild")
showClass("pC")
```

---

printGraph-methods      *Visualisation functions*

---

**Description**

Functions to plot the subgraphs induced by the most significant GO terms

**Usage**

```
showSigOfNodes(GOdata, termsP.value, firstSigNodes = 10, reverse = TRUE,
               sigForAll = TRUE, wantedNodes = NULL, putWN = TRUE,
               putCL = 0, type = NULL, showEdges = TRUE, swPlot = TRUE,
               useFullNames = TRUE, oldSigNodes = NULL, useInfo = c("none", "pval", "counts", "def", "np")
               plotFunction = GOplot, .NO.CHAR = 20)
```

```
printGraph(object, result, firstSigNodes, refResult, ...)
```

**Arguments**

|               |  |
|---------------|--|
| object        | an object of class topGOdata.  |
| GOdata        | an object of class topGOdata.  |
| result        | an object of class topGOresult.  |
| firstSigNodes | the number of top scoring GO terms which ...   |
| refResult     | an object of class topGOresult.  |
| termsP.value  | named vector of p-values.  |
| reverse       | the direction of the edges.  |
| sigForAll     | if TRUE the score/p-value of all nodes in the DAG is shown, otherwise only the score for the sigNodes  |
| wantedNodes   | the nodes that we want to find, we will plot this nodes with a different color. The vector contains the names of the nodes   |
| putWN         | the graph is generated with using the firstSigNodes and the wantedNodes.   |
| putCL         | we generate the graph from the nodes given by all previous parameters, plus their children. if putCL = 1 than only the children are added, if putCL = n we get the nodes form the next n levels. |
| type          | used for plotting pie charts   |
| showEdges     | if TRUE the edge are shown   |
| swPlot        | if true the graph is plotted, if not no plotting is done.  |
| useInfo       | additional info to be plotted to each node.  |



```

oldSigNodes      used to plot the (new) sigNodes in the same color range as the old ones
useFullNames     argument for internal use ..
plotFunction     argument for internal use ..
.NO.CHAR        argument for internal use ..
...             Extra arguments for printGraph can be:
                fn.prefix character string giving the file name prefix.
                useInfo  as in showSigOfNodes function.
                pdfSW   logical attribute switch between PDF or PS formats.

```

## Details

There are two functions available. The `showSigOfNodes` will plot the induced subgraph to the current graphic device. The `printGraph` is a warping function for `showSigOfNodes` and will save the resulting graph into a PDF or PS file.

In the plots, the significant nodes are represented as rectangles. The plotted graph is the upper induced graph generated by these significant nodes.

## Author(s)

Adrian Alexa

## See Also

[groupStats-class](#), [getSigGroups-methods](#)

## Examples

```

## Not run:
data(Godata)
data(results.tGO)

showSigOfNodes(Godata, score(resultFisher), firstSigNodes = 5, useInfo = 'all')
printGraph(Godata, resultFisher, firstSigNodes = 5, fn.prefix = "sampleFile", useInfo = "all", pdfSW = TRUE)

## End(Not run)

```

---

|                 |                          |
|-----------------|--------------------------|
| topGodata-class | <i>Class "topGodata"</i> |
|-----------------|--------------------------|

---

## Description

TODO: The node attributes are environments containing the genes/probes annotated to the respective node

If `genes` is a numeric vector than this should represent the gene's score. If it is factor it should discriminate the genes in interesting genes and the rest

TODO: it will be a good idea to replace the `allGenes` and `allScore` with an `ExpressionSet` class. In this way we can use tests like `global test`, `globalAncova....` – ALL variables starting with `.` are just for internal class usage (private)

## Objects from the Class

Objects can be created by calls of the form `new("topGOdata", ontology, allGenes, geneSelectionFun, description, annotationFun, ...)`. `~~` describe objects here `~~`

## Slots

`description`: Object of class "character" `~~`  
`ontology`: Object of class "character" `~~`  
`allGenes`: Object of class "character" `~~`  
`allScores`: Object of class "ANY" `~~`  
`geneSelectionFun`: Object of class "function" `~~`  
`feasible`: Object of class "logical" `~~`  
`nodeSize`: Object of class "integer" `~~`  
`graph`: Object of class "graphNEL" `~~`  
`expressionMatrix`: Object of class "matrix" `~~`  
`phenotype`: Object of class "factor" `~~`

## Methods

**allGenes** signature(object = "topGOdata"): ...  
**attrInTerm** signature(object = "topGOdata", attr = "character", whichGO = "character"): ...  
 ...  
**attrInTerm** signature(object = "topGOdata", attr = "character", whichGO = "missing"): ...  
 ...  
**countGenesInTerm** signature(object = "topGOdata", whichGO = "character"): ...  
**countGenesInTerm** signature(object = "topGOdata", whichGO = "missing"): ...  
**description<-** signature(object = "topGOdata"): ...  
**description** signature(object = "topGOdata"): ...  
**feasible<-** signature(object = "topGOdata"): ...  
**feasible** signature(object = "topGOdata"): ...  
**geneScore** signature(object = "topGOdata"): ...  
**geneSelectionFun<-** signature(object = "topGOdata"): ...  
**geneSelectionFun** signature(object = "topGOdata"): ...  
**genes** signature(object = "topGOdata"): A method for obtaining the list of genes, as a character vector, which will be used in the further analysis.  
**numGenes** signature(object = "topGOdata"): A method for obtaining the number of genes, which will be used in the further analysis. It has the same effect as: `length(genes(object))`.  
**sigGenes** signature(object = "topGOdata"): A method for obtaining the list of significant genes, as a character vector.  
**genesInTerm** signature(object = "topGOdata", whichGO = "character"): ...  
**genesInTerm** signature(object = "topGOdata", whichGO = "missing"): ...  
**getSigGroups** signature(object = "topGOdata", test.stat = "classicCount"): ...  
**getSigGroups** signature(object = "topGOdata", test.stat = "classicScore"): ...  
**graph<-** signature(object = "topGOdata"): ...

```

graph signature(object = "topGOdata"): ...
initialize signature(.Object = "topGOdata"): ...
ontology<- signature(object = "topGOdata"): ...
ontology signature(object = "topGOdata"): ...
termStat signature(object = "topGOdata", whichGO = "character"): ...
termStat signature(object = "topGOdata", whichGO = "missing"): ...
updateGenes signature(object = "topGOdata", geneList = "numeric", geneSelFun = "function"):
...
updateGenes signature(object = "topGOdata", geneList = "factor", geneSelFun = "missing"):
...
updateTerm<- signature(object = "topGOdata", attr = "character"): ...
usedGO signature(object = "topGOdata"): ...

```

**Author(s)**

Adrian Alexa

**See Also**

[buildLevels](#), [annFUN](#)

**Examples**

```

## load the dataset
data(geneList)
library(package = affyLib, character.only = TRUE)

## the distribution of the adjusted p-values
hist(geneList, 100)

## how many differentially expressed genes are:
sum(topDiffGenes(geneList))

## build the topGOdata class
GOdata <- new("topGOdata",
             ontology = "BP",
             allGenes = geneList,
             geneSel = topDiffGenes,
             description = "GO analysis of ALL data: Differential Expression between B-cell and T-cell",
             annot = annFUN.db,
             affyLib = affyLib)

## display the GOdata object
GOdata

#####
## Examples on how to use the methods
#####

## description of the experiment
description(GOdata)

## obtain the genes that will be used in the analysis

```

```

a <- genes(GOdata)
str(a)
numGenes(GOdata)

## obtain the score (p-value) of the genes
selGenes <- names(geneList)[sample(1:length(geneList), 10)]
gs <- geneScore(GOdata, whichGenes = selGenes)
print(gs)

## if we want an unnamed vector containing all the feasible genes
gs <- geneScore(GOdata, use.names = FALSE)
str(gs)

## the list of significant genes
sg <- sigGenes(GOdata)
str(sg)
numSigGenes(GOdata)

## to update the gene list
.geneList <- geneScore(GOdata, use.names = TRUE)
GOdata ## more available genes
GOdata <- updateGenes(GOdata, .geneList, topDiffGenes)
GOdata ## the available genes are now the feasible genes

## the available GO terms (all the nodes in the graph)
go <- usedGO(GOdata)
length(go)

## to list the genes annotated to a set of specified GO terms
sel.terms <- sample(go, 10)
ann.genes <- genesInTerm(GOdata, sel.terms)
str(ann.genes)

## the score for these genes
ann.score <- scoresInTerm(GOdata, sel.terms)
str(ann.score)

## to see the number of annotated genes
num.ann.genes <- countGenesInTerm(GOdata)
str(num.ann.genes)

## to summarise the statistics
termStat(GOdata, sel.terms)

```

---

topGOresult-class      *Class "topGOresult"*

---

## Description

Class instance created by [getSigGroups-methods](#) or by `runTest`

## Objects from the Class

Objects can be created by calls of the form `new("topGOresult", description, score, testName, algorithm, geneData)`.

**Slots**

**description:** character string containing a short description on how the object was build.  
**score:** named numerical vector containing the p-values or the scores of the tested GO terms.  
**testName:** character string containing the name of the test statistic used.  
**algorithm:** character string containing the name of the algorithm used.  
**geneData:** list containing summary statistics on the genes/gene universe/annotations.

**Methods**

**score:** method to access the score slot.  
**testName:** method to access the testName slot.  
**algorithm:** method to access the algorithm slot.  
**geneData:** method to access the geneData slot.  
**show:** method to print the object.  
**combineResults:** method to aggregate two or more topGOresult objects. `method = c("gmean", "mean", "median", "min", "max")` provides the way the object scores (which most of the time are p-values) are combined..

**Author(s)**

Adrian Alexa

**See Also**

[groupStats-class](#), [getSigGroups-methods](#)

**Examples**

```
data(results.tGO)

s <- score(resultFisher)

go <- sort(names(s))
go.sub<- sample(go, 100)
go.mixed <- c(sample(go, 50), sample(ls(GOCCTerm), 20))
go.others <- sample(ls(GOCCTerm), 100)

str(go)
str(go.sub)
str(go.mixed)
str(go.others)

str(score(resultFisher, whichGO = go))
str(score(resultFisher, whichGO = go.sub))
str(score(resultFisher, whichGO = go.mixed))
str(score(resultFisher, whichGO = go.others))

avgResult <- combineResults(resultFisher, resultKS)
avgResult
combineResults(resultFisher, resultKS, method = "min")
```

---

weightCount-class      *Class "weightCount"*

---

### Description

~~ A concise (1-5 lines) description of what the class is. ~~

### Details

TODO: Some details here.....

### Objects from the Class

Objects can be created by calls of the form `new("weightCount", testStatistic, name, allMembers, groupMembers, sigMembers, weights, sigRatio, penalise, ...)`.

### Slots

weights: Object of class "numeric" ~~  
sigRatio: Object of class "function" ~~  
penalise: Object of class "function" ~~  
roundFun: Object of class "function" ~~  
significant: Object of class "integer" ~~  
name: Object of class "character" ~~  
allMembers: Object of class "character" ~~  
members: Object of class "character" ~~  
testStatistic: Object of class "function" ~~  
testStatPar: Object of class "list" ~~

### Extends

Class "[classicCount](#)", directly. Class "[groupStats](#)", by class "classicCount", distance 2.

### Methods

No methods defined with class "weightCount" in the signature.

### Author(s)

Adrian Alexa

### See Also

[groupStats-class](#), [getSigGroups-methods](#)

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