

# Package ‘FoldGO’

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**Type** Package

**Title** Package for Fold-specific GO Terms Recognition

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**Description** FoldGO is a package designed to annotate gene sets derived from expression experiments and identify fold-change-specific GO terms.

**Depends** R (>= 4.0)

**License** GPL-3

**Encoding** UTF-8

**LazyData** true

**biocViews** DifferentialExpression, GeneExpression, GO, Software

**RoxygenNote** 6.1.0

**Suggests** knitr, rmarkdown, devtools, kableExtra

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examdata_bg	<i>Background sets of genes used in examples</i>
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## Description

We used genes from two datasets in examples:

1. RNA-seq experiment on auxin treatment of Arabidopsis thaliana roots (degenes)
2. RNA-seq experiment on mRNA differential expression in LNCaP cells expressing the wild-type androgen receptor (AR-WT) or the ligand-independent AR-V7 splice variant (degenes\_hum)

## Usage

bggenes

bggenes\_hum

## Format

A vector containing the GeneIDs with 18039 and 38238 for A. thaliana and H. sapiens correspondingly

## Source

1. A. thaliana and auxin: <https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE97258>
2. H. sapiens LNCap AR-V7: <https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE71334>

## Examples

```
# load background genes from A. thaliana RNA-seq experiment
data("bggenes")
```

---

`examdata_degs`*Differential expressed genes used in examples*

---

## Description

We used two datasets in examples:

1. RNA-seq experiment on auxin treatment of *Arabidopsis thaliana* roots (degenes)
2. RNA-seq experiment on mRNA differential expression in LNCaP cells expressing the wild-type androgen receptor (AR-WT) or the ligand-independent AR-V7 splice variant (degenes\_hum)

## Usage

`degenes``degenes_hum`

## Format

A dataframes with 4 variables and 789 and 2079 for *A. thaliana* and *H. sapiens* correspondingly, where colnames are:

**GeneID** Gene identifier

**FC** fold-change value

**pval** p-value

**qval** Benjamini-Yekutieli adjusted p-value

## Source

1. *A. thaliana* and auxin: <https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE97258>
2. *H. sapiens* LNCap AR-V7: <https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE71334>

## Examples

```
# load degenes from RNA-seq experiment on auxin treatment of Arabidopsis thaliana roots
data("degenes")
```

---

examdata_objs	<i>Precompiled objects of GeneGroups, FuncAnnotGroups classes used in examples</i>
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---

### Description

**up\_groups** object of GeneGroups class compiled from up-regulated genes from rna-seq experiment on auxin treatment of Arabidopsis thaliana roots

**down\_groups** object of GeneGroups class compiled from down-regulated genes from rna-seq experiment on auxin treatment of Arabidopsis thaliana roots

**up\_annotobj** object of FuncAnnotGroups class compiled from lists of up-regulated genes from rna-seq experiment on auxin treatment of Arabidopsis thaliana roots

**up\_annotobj** object of FuncAnnotGroups class compiled from lists of down-regulated genes from rna-seq experiment on auxin treatment of Arabidopsis thaliana roots

### Usage

up\_groups

down\_groups

up\_annotobj

down\_annotobj

### Format

**up\_groups** object of GeneGroups class

**down\_groups** object of GeneGroups class

**up\_annotobj** object of FuncAnnotGroupsTopGO class

**up\_annotobj** object of FuncAnnotGroupsTopGO class

### Examples

```
# load GeneGroups object with up-regulated genes from rna-seq experiment on auxin treatment
# of Arabidopsis thaliana roots
data("up_groups")
# load FuncAnnotGroups object compiled from lists of up-regulated genes
# from rna-seq experiment on auxin treatment of Arabidopsis thaliana roots
data("up_annotobj")
```

---

fagroupstopgo\_class    *S4 class for FuncAnnotGroupsTopGO object*

---

### Description

This function conducts functional enrichment analysis for sets of genes generated by [GeneGroups](#) function.

### Constructor

FuncAnnotGroupsTopGO(groups, namespace, customAnnot, annot, bggenes, . . . ), where:

groups - object of [GeneGroups](#) class

namespace - character string specifying GO namespace ("BP", "MF" or "CC")

customAnnot - Use if mapping argument is set to "custom". It can be an object generated by [GAFReader](#) or readGAF function from mgsa package or list which has GO term ids as keys and character vectors contain gene ids as values.

annot - from TopGO manual: 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.

bggenes - vector contains background set of genes

... - other parameters:

genesannot - minimal number of genes annotated to a term in the annotation. 1 by default

algorithm - from TopGO manual: character string specifying which algorithm to use. The algorithms are shown by the topGO whichAlgorithms() function. "classic" by default

statistic - from TopGO manual: character string specifying which test to use. The statistical tests are shown by the topGO whichTests() function. "fisher" by default

mapping - from TopGO manual: character string specifying the name of the Bioconductor package containing the gene mappings for a specific organism. For example: mapping = "org.Hs.eg.db". "custom" by default

ID - from TopGO manual: character string specifying the gene identifier to use. Currently only the following identifiers can be used: c("entrez", "genbank", "alias", "ensembl", "symbol", "genename", "unigene")

### Accessors

In the code examples below object is an object of FuncAnnotGroupsTopGO class

getResultList(object) - returns list of functional annotation result tables

**Examples**

```
# read .gaf file (in this example gaf file with annotation for \emph{A.thaliana} is used)
library(topGO)
gaf_path <- system.file("extdata", "gene_association.tair.lzma",
                        package = "FoldGO", mustWork = TRUE)
# read gaf file and convert annotation in the list format
# contains GO term id's as keys and Gene ID's as values
gaf <- GAFReader(file = gaf_path, geneid_col = 10)
# split DEG genes into quantiles
gene_groups <- GeneGroups(degenes, 2)
# run enrichment test
annotobj <- FuncAnnotGroupsTopGO(gene_groups, "BP", customAnnot = gaf,
                                annot = topGO::annFUN.GO2genes,
                                bggenes = bggenes, padjmethod = "BH",
                                qitborder = 10, genesannot = 1)

# get results of functional enrichment analysis in a tabular form:
getResultList(annotobj)
```

---

foldspectest\_class      *FoldSpecTest S4 class*

---

**Description**

FoldSpecTest object calculates test on fold-specificity and stores all resulting data needed for further analysis. It takes object which is instance of subclass of AnnotGroups class (e.g. FuncAnnotGroupsTopGO class) as a minimal set of input parameters. For more details see Constructor section.

**Constructor**

FoldSpecTest(annotgroups, fdrstep1, fdrstep2, padjmethod, fisher\_alternative), where:

annotgroups - object of FuncAnnotGroups class

fdrstep1 - FDR threshold for 1 step of fold-specificity recognition procedure

fdrstep2 - FDR threshold for 2 step of fold-specificity recognition procedure

padjmethod - method for multiple testing correction (to see all possible methods print: p.adjust.methods)  
Benjamini-Hochberg by default

fisher\_alternative - indicates the alternative hypothesis and must be one of "two.sided", "greater" or "less". You can specify just the initial letter. Only used in the 2 by 2 case.

**Accessors**

In the code examples below object is an object of FoldSpecTest class

getFStable(object) - returns dataframe with fold-change-specific terms and related data

getNFStable(object) - returns dataframe with not fold-change-specific terms and related data

getResultTable(object) - returns dataframe with both fold-change-specific and not fold-change-specific terms

getWholeIntName(object) - returns name of largest fold-change interval (DEGs interval)

## Examples

```
# FoldSpecTest function requires only object of FuncAnnotGroups class as a
# minimal set of parameters. In the example up_annotobj is an object of FuncAnnotGroups class
# compiled from lists of up-regulated genes from rna-seq experiment on auxin treatment
# of Arabidopsis thaliana roots [FoldGO::up_annotobj].
FoldSpecTest(up_annotobj)

# FoldSpecTest function with custom parameters
fs_up <- FoldSpecTest(up_annotobj, fdrstep1 = 0.2, fdrstep2 = 0.01, padjmethod = "BY")

# get dataframe with fold-change-specific terms
getFStable(fs_up)

# get dataframe with not fold-change-specific terms
getNFStable(fs_up)

# get dataframe with both fold-change-specific and not fold-change-specific terms
getResultTable(fs_up)

# get name of largest fold-change interval (DEGs interval)
getWholeIntName(fs_up)
```

---

`gafreader_class`      *S4 class for GAFReader object*

---

## Description

Parser for annotation presented in GAF file format (.gaf). GAFReader function returns object which contains as a dataframe annotation as it presented in initial file. Via GAFReader accessor method one can retrieve annotations as list GO term id's as keys and Gene ID's as values and version of file (see Accessors section).

## Constructor

GAFReader(file = gaf\_path, geneid\_col = 10), where:

file - full path to annotation file

geneid\_col - index of column with Gene ID (2 by default)

## Accessors

In the code examples below object is an object of GAFReader class

getVersion(object) - returns version of GAF file

getAnnotation(object) - returns annotation from GAF file in form of GO ids - Gene ids list

**Methods**

In the code examples below object is an object of GAFReader class

getAnnotation(object) - Convert annotation to list contains GO term id's as keys and Gene ID's as values

**Examples**

```
# read .gaf file (in this example gaf file with annotation for A.thaliana is used)
# object returned by \link{GAFReader} can be used by
# \link{FuncAnnotGroupsTopGO} function.
gaf_path <- system.file("extdata", "gene_association.tair.lzma",
                        package = "FoldGO", mustWork = TRUE)
gaf <- GAFReader(file = gaf_path, geneid_col = 10)
# get version of file
getVersion(gaf)
# get annotation in the list format contains GO term id's as keys and Gene ID's as values
getAnnotation(gaf)
```

---

genegroups\_class

*S4 class for Gene Groups*

---

**Description**

This function splits gene list into quantiles and generates all unions of neighbouring quantiles. It takes dataframe with genes ID's and fold values, number of quantiles and logical variable which must set to TRUE if fold values are presented in logarithmic scale, otherwise it must be set to FALSE value (TRUE by default) as parameters.

**Constructor**

GeneGroups(inputtable, quannumber, logfold), where:

inputtable - dataframe contains initial set of genes gene ID's in the first row and corresponding fold change values in the second row

quannumber - number of quantiles (e.g. 2,3,4...)

logfold - TRUE if fold values are presented in log scale, otherwise is FALSE

**Accessors**

In the code examples below object is an object of GeneGroups class

getGroups(object) - returns list of gene sets for each quatile and all combinations

getWholeIntName(object) - returns name of the interval containing all differentially expressed genes

getQuanNumber(object) - returns number of quantiles

getIntNames(object) - returns vector of intervals names

getRegType(object) - returns regulation type



## Examples

```
# split initial gene set into quantiles
gene_groups <- GeneGroups(degenes, 6)
# get list of gene sets for each quatile and all combinations
getGroups(gene_groups)
# get name of the interval containing all differentially expressed genes
getWholeIntName(gene_groups)
# get number of quantiles
getQuanNumber(gene_groups)
# get vector of intervals names
getIntNames(gene_groups)
# get regulation type
getRegType(gene_groups)
```

---

getAnnotation	<i>Get annotation derived from annotation file</i>
---------------	--

---

## Description

This method allows to retrieve annotation from MgsaSets or [GAFReader](#) class object in form of list contains GO term id's as keys and Gene ID's as values

## Usage

```
getAnnotation(object)

## S4 method for signature 'AnnotationReader'
getAnnotation(object)

## S4 method for signature 'list'
getAnnotation(object)

## S4 method for signature 'MgsaSets'
getAnnotation(object)

## S4 method for signature ``NULL``
getAnnotation(object)
```

## Arguments

object           - Object of mgsa package MgsaSets class or FoldGO [GAFReader](#) class

## Value

list contains GO term id's as keys and Gene ID's as values

**Examples**

```
## Not run:
gaf_path <- system.file("extdata", "gene_association.tair.lzma",
                        package = "FoldGO", mustWork = TRUE)
gaf <- GAFReader(file = gaf_path, geneid_col = 10)
getAnnotation(gaf)

## End(Not run)
```

---

`getWholeIntName`      *getWholeIntName S4 method*

---

**Description**

This method returns name of the interval containing all differentially expressed genes. It can be applied to objects of GeneGroups and FoldSpecTest classes

**Arguments**

`object`              Object of GeneGroups or FoldSpecTest class

**See Also**

[FoldSpecTest GeneGroups](#)

**Examples**

```
# GeneGroups class object example
gene_groups <- GeneGroups(degenes, 6)
getWholeIntName(gene_groups)
# FoldSpecTest class object example
fs_up <- FoldSpecTest(up_annotobj)
getWholeIntName(fs_up)
```

---

`plot,FoldSpecTest,ANY-method`  
*Fold-change specific GO Profile chart plotting*

---

**Description**

Fold-change specific GO Profile chart plotting

**Usage**

```
## S4 method for signature 'FoldSpecTest,ANY'
plot(x, y, x_text_size = 10)
```

**Arguments**

- x - object of S4 FoldSpecTest class with up-regulated genes
- y - object of S4 FoldSpecTest class with down-regulated genes
- x\_text\_size - x axis labels size

**Value**

- Fold-change specific GO Profile plot

**Examples**

```
# calculate fold-specificity test for up-regulated genes
up_fs <- FoldSpecTest(up_annotobj)
# calculate fold-specificity test for down-regulated genes
down_fs <- FoldSpecTest(down_annotobj)
plot(up_fs, down_fs)
```

---

rna_seq_data	<i>Data from rna-seq experiment on auxin treatment of Arabidopsis thaliana roots</i>
--------------	--

---

**Description**

A dataset containing the GeneIDs and corresponding fold-change values.

**Usage**

```
rna_seq_data
```

**Format**

A data frame with 18039 rows and 4 variables:

- GeneID** Gene identifier
- FC** fold-change value
- pval** p-value
- qval** Benjamini-Yekutieli adjusted p-value

**Source**

<https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE97258>

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