# Package ‘GOFunction’

March 22, 2017

## Type
Package

## Title
GO-function: deriving biologically relevant functions from statistically significant functions

## Version
1.22.0

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2013-10-03

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## Description
The GO-function package provides a tool to address the redundancy that result from the GO structure or multiple annotation genes and derive biologically relevant functions from the statistically significant functions based on some intuitive assumption and statistical testing.

## License
GPL (>= 2)

## LazyLoad
yes

## Depends
R (>= 2.11.0), methods, Biobase (>= 2.8.0), graph (>= 1.26.0), Rgraphviz (>= 1.26.0), GO.db (>= 2.4.1), AnnotationDbi (>= 1.10.2), SparseM (>= 0.85)

## Imports
methods, Biobase, graph, Rgraphviz, GO.db, AnnotationDbi, DBI, SparseM

## Collate

## biocViews
GO, Pathways, Microarray, GeneSetEnrichment

## NeedsCompilation
no

## R topics documented:

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GOFunction-package

Description
The GO-function package is an enrichment analysis tool for Gene Ontology (GO). According to some explicit rules, it is designed for treating the redundancy resulting from the GO structure or multiple annotation genes. Different from current redundancy treatment tools simply based on some numerical considerations, GO-function can find terms which are both statistically interpretable and biologically meaningful.

Details

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Author(s)
Jing Wang Maintainer: Jing Wang <jingwang.uestc@gmail.com>

References
Jing Wang et al. GO-function: deriving biologically relevant functions from statistically significant functions, Brief Bioinform, 2012, 13(2): 216-227

See Also
GOFunction

createGODAG

Description
To plot the relationship between statistically significant GO terms, this function creates a GO DAG structure for these terms.
enrichmentFunction

Arguments

sigNodes sigNodes is the statistically significant GO terms found by "enrichmentFunction" function.
ontology The default ontology is "BP" (Biological Process). The "CC" (Cellular Component) and "MF" (Molecular Function) ontologies can also be used.

Value

This function returns a object of 'graphNEL' class.

Note

This function simulates the related program in TopGO (Alexa, A. et al. (2006) Improved scoring of functional groups from gene expression data by decorrelating GO graph structure. Bioinformatics, 22, 1600-1607).

Author(s)

Jing Wang

See Also

GOFunction enrichmentFunction

enrichmentFunction Identification of statistically significant GO terms

Description

Using the hypergenomic distribution test and FDR correction procedure, this function can identify a set of statistically significant GO terms.

Arguments

annRef annRef is the annotated reference genes and their annotated terms.
annInterest annInterest is the annotated interesting genes and their annotated terms.
method method is the fdr method. GO-function provides three p value correction methods: "bonferroni", "BH" and "BY". The default is "BY".
fdrth fdrth is the fdr cutoff to identify statistically significant GO terms. The default is 0.05.

Value

The function returns a list contained two values: The first value is a table contained the information of all statistically significant terms under a FDR control level and the second value is a table contained the information of all annotated GO terms.

Author(s)

Jing Wang
globalRedundancy

See Also

GOFunction

globalRedundancy

Treating for glocal redundancy between GO terms which share multiple function genes but have no ancient-offspring relationship

Description

For a pair of terms with overlapping genes, this function can identify whether their significance might be simply introduced by the overlapping genes (see details).

Arguments

generalAnn
generalAnn is the mapping between gene and GO terms.
sigTermRelation
sigTermRelation is the GO DAG relationship between the statistically significant terms.
annRef
annRef is the annotated reference genes and their annotated terms.
annInterest
annInterest is the annotated interesting genes and their annotated terms.
sigTermRedun
sigTermRedun is the remained statistically significant terms after treating local redundancy.
poth
poth is the significant level to test whether the overlapping genes of one term is significantly different from the non-overlapping genes of the term. The default is 0.05.
peth
peth is the significant level to test whether the non-overlapping genes of one term is enriched with interesting genes. The default is 0.05.

Details

This function uses the following principles to treat for glocal redundancy between GO terms which share multiple function genes but have no ancient-offspring relationship. For a pair of overlapping terms, GO-function remains one term only if (1) there is additional evidence that the non-overlapping genes of a term may be related to the disease if the frequency of interesting genes in these genes is not significantly different from that in the overlapping genes or is significantly higher than the random background; and (2) there is no such evidence for the non-overlapping genes of another term. In all the other situations, GO-function remains both terms.

Value

The function returns a set of remained terms with evidence that their significance should not be simply due to the overlapping genes.

Author(s)

Jing Wang

See Also

GOFunction localRedundancy
Description

The GOFunctio function is the main function of the GO-function package and can generate a set of biologically relevant GO terms.

Usage

GOFunctio(interestGenes, refGenes, organism = "org.Hs.eg.db", ontology = "BP", fdrmethod = "BY", fdrth = 0.05, ppth = 0.05, pcth = 0.05, poth = 0.05, peth = 0.05, bmpSize = 2000, filename = "sigTerm")

Arguments

- **interestGenes**: interestGenes is a set of interesting genes (e.g. differential expressed genes), which should be denoted using the Entrez gene ID.
- **refGenes**: refGenes is the background genes corresponding to the interesting genes, which should be denoted using the Entrez gene ID.
- **organism**: The GO-function package can be currently applied to analyse data for 18 organisms and the user should install the corresponding gene annotation package when analysing data for these organisms. The 18 organisms and the corresponding packages are as follows: Anopheles "org.Ag.eg.db", Bovine "org.Bt.eg.db", Canine "org.Cf.eg.db", Chicken "org.Gg.eg.db", Chimp "org.Pt.eg.db", E.coli strain K12 "org.EcK12.eg.db", E.coli strain Sakai "org.EcSakai.eg.db", Fly "org.Dm.eg.db", Human "org.Hs.eg.db", Mouse "org.Mm.eg.db", Pig "org.Ss.eg.db", Rat "org.Rn.eg.db", Rhesus "org.Mmu.eg.db", Streptomyces coelicolor "org.Sco.eg.db", Worm "org.Ce.eg.db", Xenopus "org.Xl.eg.db", Yeast "org.Sc.sgd.db", Zebrafish "org.Dr.eg.db". The default organism is "org.Hs.eg.db" (Human).
- **ontology**: The default ontology is "BP" (Biological Process). The "CC" (Cellular Component) and "MF" (Molecular Function) ontologies can also be used.
- **fdrmethod**: GO-function provides three p value correction methods: "bonferroni", "BH" and "BY". The default fdrmethod is "BY".
- **fdrth**: fdrth is the fdr cutoff to identify statistically significant GO terms. The default is 0.05.
- **ppth**: ppth is the significant level to test whether the remaining genes of the ancestor term are enriched with interesting genes after removing the genes in its significant offspring terms. The default is 0.05.
- **pcth**: pcth is the significant level to test whether the frequency of interesting genes in the offspring terms are significantly different from that in the ancestor term. The default is 0.05.
- **poth**: poth is the significant level to test whether the overlapping genes of one term is significantly different from the non-overlapping genes of the term. The default is 0.05.
- **peth**: peth is the significant level to test whether the non-overlapping genes of one term is enriched with interesting genes. The default is 0.05.
- **bmpSize**: bmpSize is the width and height of the plot of GO DAG for all statistically significant terms. GO-function set the default width and height of the plot as 2000 pixels in order to clearly show the GO DAG structure. If the GO DAG is
very complexity, the user should increase \texttt{bmpSize}. Note: If there is an error at the step of "\texttt{bmp(filename, width = 2000, ...}" when running GO-function, the user should decrease \texttt{bmpSize}.

\texttt{filename} is the name of the files saving the table and the GO DAG of all statistically significant terms.

**Value**

There are two types of result output of GO-function. The first type is that GO-function saves a table contained all statistically significant terms to a CSV file (e.g. "sigTerm.csv") in the current working folder. This table contains seven columns: goid, name, refnum (the number of the reference genes in a GO term), interestnum (the number of the interesting genes in a GO term), pvalue, adjustp (the corrected p value by the fdr control), FinalResults. The "FinalResults" contains three types: (1) "Local" represents terms removed after treating for local redundancy; (2) "Global" represents terms removed after treating for global redundancy; (3) "Final" represents the remained terms with evidence that their significance should not be simply due to the overlapping genes. GO-function also saves the structure of GO DAG for all statistically significant terms into a plot (e.g. "sigTerm.bmp") in the current working folder. In this plot, "circle", "box" and "rectangle" represent "Local", "Global" and "Final" terms in the table, respectively. The different color shades represent the adjusted p values of the terms.

**Note**

GO-function use the GO data and annotation data from Bioconductor, so the user does not need to update the data manually.

**Author(s)**

Jing Wang

**Examples**

```r
data(exampledata)
sigTerm <- GOFunction(interestGenes, refGenes, organism = "org.Hs.eg.db", ontology= "BP", fdrmethod = "BY", fdrth = 0.05, ppth = 0.05, pcth = 0.05, poth = 0.05, peth = 0.05, bmpSize = 2000, filename="sigTerm")
```

**interestGenes**

Colon cancer differentially expressed genes

**Description**

The interestGenes contain 9201 differentially expressed genes extracted from Sabates-Bellver dataset.

**Usage**

```r
data(exampledata)
```

**Format**

vector
Details

The differently expressed genes are selected using the Significant Analysis of Microarray (SAM) with an FDR of 1.

References


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**localRedundancy**

Treating for local redundancy between GO terms with ancient-offspring relationship

Description

This function uses some explicit rules to treat local redundancy (see details).

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sigTerm</td>
<td>sigTerm is the statistically significant terms found by the enrichmentFunction function.</td>
</tr>
<tr>
<td>generalAnn</td>
<td>generalAnn is the mapping between gene and GO terms.</td>
</tr>
<tr>
<td>sigTermRelation</td>
<td>sigTermRelation is the GO DAG relationship between the statistically significant terms.</td>
</tr>
<tr>
<td>annRef</td>
<td>annRef is the annotated reference genes and their annotated terms.</td>
</tr>
<tr>
<td>annInterest</td>
<td>annInterest is the annotated interesting genes and their annotated terms.</td>
</tr>
<tr>
<td>ppth</td>
<td>ppth is the significant level to test whether the remaining genes of the ancestor term are enriched with interesting genes after removing the genes in its significant offspring terms. The default is 0.05.</td>
</tr>
<tr>
<td>pcth</td>
<td>pcth is the significant level to test whether the frequency of interesting genes in the offspring terms are significantly different from that in the ancestor term. The default is 0.05.</td>
</tr>
</tbody>
</table>

Details

This function uses three principles to treat local redundancy between GO terms with ancient-offspring relationship: 1. if the frequency of interesting genes in the remaining genes of the ancestor term is not significantly higher than the random background, and at the same time, it is lower than the frequency of its significant offspring terms, GO-function only remains the offspring terms; Otherwise, GO-function remains ancient term. In this situation, 2. if the offspring terms are no different with the ancient term, GO-function only remains the ancestor term; otherwise, 3. GO-function remains both ancient term and its offspring terms.

Value

The function returns a set of remained terms without local redundancy.
showSigNodes

Author(s)
Jing Wang

See Also
- GOFunction enrichmentFunction

refGenes
Colon cancer background genes

Description
The refGenes contain 19950 background genes.

Usage
data(exampledata)

Format
vector

References

showSigNodes
Drawing the GO DAG structure of statistically significant terms

Description
According to the GO DAG structure created by the "createGODAG" function, this function draws the corresponding plot.

Arguments
- **DAG**: DAG is a object of 'graphNEL' class which contains the GO DAG structure of statistically significant GO terms.
- **sigTerm**: sigTerm is the GO terms found by enrichmentFunction function.
- **sigTerm_Local**: sigTerm_Local is the remained statistically significant terms after treating local redundancy.
- **sigTerm_Global**: sigTerm_Global is the remained statistically significant terms after treating global redundancy.
- **dagTermInfo**: dagTermInfo is the information of all related GO terms in GO DAG.
bmpSize is the width and height of the plot of GO DAG for all statistically significant terms. GO-function set the default width and height of the plot as 2000 pixels in order to clearly show the GO DAG structure. If the GO DAG is very complexity, the user should increase bmpSize. Note: If there is an error at the step of "bmp(filename, width = 2000, ...)" when running GO-function, the user should decrease bmpSize.

filename is the name of the files saving the table and the GO DAG of all statistically significant terms.

Value

This function saves the structure of GO DAG for all statistic significant terms into a plot (e.g. "sigTerm.bmp") in the current working folder. In this plot, "circle" represents terms removed after local redundancy treatment, "box" represents terms removed after treating global redundancy and "rectangle" represents the remained terms with evidence that their significance should not be simply due to the overlapping genes. The different color shades represent the adjusted p values of the terms.

Author(s)

Jing Wang

See Also

GOFunction enrichmentFunction localRedundancy globalRedundancy createGODAG
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