

Package ‘ViSEAGO’

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Title ViSEAGO: a Bioconductor package for clustering biological functions using Gene Ontology and semantic similarity

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Imports data.table, AnnotationDbi, AnnotationForge, biomaRt, dendextend, DiagrammeR, DT, dynamicTreeCut, fgsea, GOSemSim, ggplot2, GO.db, grDevices, heatmaply, htmlwidgets, igraph, methods, plotly, processx, topGO, RColorBrewer, R.utils, scales, stats, UpSetR, utils

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Description The main objective of ViSEAGO package is to carry out a data mining of biological functions and establish links between genes involved in the study. We developed ViSEAGO in R to facilitate functional Gene Ontology (GO) analysis of complex experimental design with multiple comparisons of interest. It allows to study large-scale datasets together and visualize GO profiles to capture biological knowledge. The acronym stands for three major concepts of the analysis: Visualization, Semantic similarity and Enrichment Analysis of Gene Ontology. It provides access to the last current GO annotations, which are retrieved from one of NCBI Entrez-Gene, Ensembl or Uniprot databases for several species. Using available R packages and novel developments, ViSEAGO extends classical functional GO analysis to focus on functional coherence by aggregating closely related biological themes while studying multiple datasets at once. It provides both a synthetic and detailed view using interactive functionalities respecting the GO graph structure and ensuring functional coherence supplied by semantic similarity. ViSEAGO has been successfully applied on several datasets from different species with a variety of biological questions. Results can be easily shared between bioinformaticians and biologists, enhancing reporting capabilities while maintaining reproducibility.

VignetteBuilder knitr

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URL <https://www.bioconductor.org/packages/release/bioc/html/ViSEAGO.html>,
<https://forgemia.inra.fr/UMR-BOA/ViSEAGO>

BugReports <https://forgemia.inra.fr/UMR-BOA/ViSEAGO/issues>

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Collate 'genomic_ressource.R' 'Bioconductor2GO.R' 'Ensembl2GO.R'
 'EntrezGene2GO.R' 'EntrezGene_orthologs.R' 'enrich_GO_terms.R'
 'GO_SS.R' 'GO_clusters.R' 'GOclusters_heatmap.R' 'GOcount.R'
 'GOTerms_heatmap.R' 'MDSplot.R' 'Uniprot2GO.R' 'Upset.R'
 'ViSEAGO.R' 'annotate.R' 'available_organisms.R' 'gene2GO.R'
 'build_GO_SS.R' 'clusters_cor.R' 'compare_clusters.R'
 'compute_SS_distances.R' 'create_topGOdata.R' 'custom2GO.R'
 'datasets.R' 'fgsea.R' 'merge_enrich_terms.R' 'overlapper.R'
 'pkgdiagram.R' 'runfgsea.R' 'show_heatmap.R' 'show_table.R'
 'taxonomy.R'

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<code>annotate</code>	<i>Retrieve GO annotations for a specie from genomic ressource database.</i>
-----------------------	------------------------------------------------------------------------------

Description

This method retrieves and stores GO annotations for the organism of interest from one of genomic ressource database (Bioconductor, EntrezGene, Ensembl, Uniprot).

Usage

```
annotate(id, object, ortholog = FALSE)

## S4 method for signature 'character,genomic_ressource'
annotate(id, object, ortholog = FALSE)
```

Arguments

<code>id</code>	identifiant corresponding to the organism of interest. This id name is referenced in the first column of the database used (see available_organisms).
<code>object</code>	a required genomic_ressource-class object created by Bioconductor2GO , EntrezGene2GO , Ensembl2GO , or Uniprot2GO methods.
<code>ortholog</code>	logical (default to FALSE). Only available for vertebrates organisms and for object created by EntrezGene2GO method (see Details).

Details

This method uses a `genomic_ressource-class` object to retrieve GO annotations for the organism of interest. The stored annotations are structured in 3 slots corresponding to the 3 GO categories: MF (Molecular Function), BP (Biological Process), and CC (Cellular Component). Each slot contains GO terms with associated **evidence code**.

The `genomic_ressource-class` object is created by one of the four available methods: `Bioconductor2GO`, `EntrezGene2GO`, `Ensembl2GO`, or `Uniprot2GO`.

In the case of vertebrates, setting `ortholog` argument to TRUE is required if you need to add GO terms with experimental **evidence codes** from orthologs genes when using `EntrezGene2GO` method. To display organisms supported by NCBI EntrezGene orthologs pipeline, set the arguments `id=NULL` and `ortholog=TRUE`. This approach is highly similar to the strategy developed by Uniprot-GOA consortium for the Electronic Annotation Method using `Ensembl Compara`.

Value

`annotate` produces an object of `gene2GO-class` required by `build_GO_SS` method.

References

Durinck S, Spellman P, Birney E and Huber W (2009). Mapping identifiers for the integration of genomic datasets with the R/Bioconductor package `biomaRt`. *Nature Protocols*, 4, pp. 1184-1191.

Durinck S, Moreau Y, Kasprzyk A, Davis S, De Moor B, Brazma A and Huber W (2005). BioMart and Bioconductor: a powerful link between biological databases and microarray data analysis. *Bioinformatics*, 21, pp. 3439-3440.

Fong, JH, Murphy, TD, Pruitt, KD (2013). Comparison of RefSeq protein-coding regions in human and vertebrate genomes. *BMC Genomics*, 14:654.

Henrik Bengtsson (2016). `R.utils`: Various Programming Utilities. R package version 2.5.0. <https://CRAN.R-project.org/package=R.utils>.

Herve Pages, Marc Carlson, Seth Falcon and Nianhua Li (2017). `AnnotationDbi`: Annotation Database Interface. R package version 1.38.0.

Matt Dowle and Arun Srinivasan (2017). `data.table`: Extension of `data.frame`. R package version 1.10.4. <https://CRAN.R-project.org/package=data.table>.

See Also

Other `genomic_ressource`: `Bioconductor2GO()`, `Custom2GO()`, `Ensembl2GO()`, `EntrezGene2GO()`, `Uniprot2GO()`, `available_organisms()`, `genomic_ressource-class`, `taxonomy()`

Other `GO_terms`: `GOcount()`, `GOterms_heatmap()`, `create_topGOdata()`, `gene2GO-class`, `merge_enrich_terms()`, `runfgsea()`

Examples

```
## Not run:
## load Mus musculus (mouse) GO annotations

# from Bioconductor
Bioconductor<-ViSEAGO::Bioconductor2GO()
```

```
myGENE2GO<-ViSEAGO::annotate(  
  id="org.Mm.eg.db",  
  object=Bioconductor  
)  
  
# from EntrezGene  
EntrezGene<-ViSEAGO::EntrezGene2GO()  
myGENE2GO<-ViSEAGO::annotate(  
  id="10090",  
  object=EntrezGene  
)  
  
# from EntrezGene  
Ensembl<-ViSEAGO::Ensembl2GO()  
myGENE2GO<-ViSEAGO::annotate(  
  id="mmusculus_gene_ensembl",  
  object=Ensembl  
)  
  
# from Uniprot  
Uniprot<-ViSEAGO::Uniprot2GO()  
myGENE2GO<-ViSEAGO::annotate(  
  id="mouse",  
  object=Uniprot  
)  
  
## from Custom GO annotation file  
Custom<-ViSEAGO::Custom2GO(system.file("extdata/customfile.txt",package = "ViSEAGO"))  
myGENE2GO<-ViSEAGO::annotate(  
  id="myspecies1",  
  object=Custom  
)  
  
## specific options for EntrezGene database  
  
# Chicken GO annotations without adding orthologs  
EntrezGene<-ViSEAGO::EntrezGene2GO()  
myGENE2GO<-ViSEAGO::annotate(  
  id="9031",  
  object=EntrezGene  
)  
  
# Chicken GO annotation with the add of orthologs GO annotations  
EntrezGene<-ViSEAGO::EntrezGene2GO()  
myGENE2GO<-ViSEAGO::annotate(  
  id="9031",  
  object=EntrezGene,  
  ortholog=TRUE  
)  
  
# display organisms supported by NCBI EntrezGene orthologs pipeline  
EntrezGene<-ViSEAGO::EntrezGene2GO()  
ViSEAGO::annotate(  
  id="9031",  
  object=EntrezGene,  
  ortholog=TRUE  
)
```

```
    id="NULL",
    object=EntrezGene,
    ortholog=TRUE
  )

## End(Not run)
```

available_organisms *Display available organisms from a specified database.*

Description

Display an interactive table with available organisms from a genomic resource database (Bioconductor, EntrezGene, Ensembl, Uniprot).

Usage

```
available_organisms(object)

## S4 method for signature 'genomic_resource'
available_organisms(object)
```

Arguments

object a `genomic_resource-class` object created by `Bioconductor2GO`, `EntrezGene2GO`, `Ensembl2GO`, or `Uniprot2GO` methods.

Details

an interactive datatable.

Value

javascript datatable

References

Yihui Xie (2016). DT: A Wrapper of the JavaScript Library 'DataTables'. R package version 0.2. <https://CRAN.R-project.org/package=DT>

See Also

Other genomic_resource: `Bioconductor2GO()`, `Custom2GO()`, `Ensembl2GO()`, `EntrezGene2GO()`, `Uniprot2GO()`, `annotate()`, `genomic_resource-class`, `taxonomy()`

Other visualization: `GOclusters_heatmap()`, `GOcount()`, `GOterms_heatmap()`, `Upset()`, `overLapper()`, `show_heatmap()`, `show_table()`

Examples

```
# display Bioconductor table
Bioconductor<-ViSEAGO::Bioconductor2GO()
ViSEAGO::available_organisms(Bioconductor)
## Not run:

# display EntrezGene table
EntrezGene<-ViSEAGO::EntrezGene2GO()
ViSEAGO::available_organisms(EntrezGene)

# display Ensembl table
Ensembl<-ViSEAGO::Ensembl2GO()
ViSEAGO::available_organisms(Ensembl)

# display Uniprot table
Uniprot<-ViSEAGO::Uniprot2GO()
ViSEAGO::available_organisms(Uniprot)

## End(Not run)
```

Bioconductor2GO

Check available organisms databases at Bioconductor.

Description

Retrieve the Bioconductor **OrgDb** available organisms databases packages.

Usage

```
Bioconductor2GO()
```

Details

This function gives genome wide annotation for available organisms databases packages from **Bioconductor OrgDb**. It uses `loadAnnDbPkgIndex` from **AnnotationForge** package.

Value

a `genomic_ressource-class` object required by `annotate` method.

References

Carlson M and Pages H (2017). AnnotationForge: Code for Building Annotation Database Packages. R package version 1.18.0.

See Also

Other `genomic_ressource`: `Custom2GO()`, `Ensembl2GO()`, `EntrezGene2GO()`, `Uniprot2GO()`, `annotate()`, `available_organisms()`, `genomic_ressource-class`, `taxonomy()`

Examples

```
# Check Bioconductor OrgDb available organisms
Bioconductor<-ViSEAGO::Bioconductor2GO()
```

build_GO_SS	<i>build GO Semantic Similarity object.</i>
-------------	---------------------------------------------

Description

Compute the Information content (IC) on the given ontology, and create a [GO_SS-class](#) object required by [compute_SS_distances](#) method to compute GO semantic similarity between enriched GO terms or groups of terms.

Usage

```
build_GO_SS(gene2GO, enrich_GO_terms)

## S4 method for signature 'gene2GO,enrich_GO_terms'
build_GO_SS(gene2GO, enrich_GO_terms)
```

Arguments

gene2GO a [gene2GO-class](#) object from [annotate](#) method.
enrich_GO_terms a [enrich_GO_terms-class](#) from [merge_enrich_terms](#) method.

Details

This method use [annotate](#) and [merge_enrich_terms](#) output objects (see Arguments), and compute the Information content (IC) using the internal code of [godata](#) function from **GOSemSim** package.

Value

a [GO_SS-class](#) object required by [compute_SS_distances](#).

References

Alexa A, Rahnenfuhrer J, Lengauer T. Improved scoring of functional groups from gene expression data by decorrelating GO graph structure. *Bioinformatics* 2006; 22:1600-1607.

Guangchuang Yu, Fei Li, Yide Qin, Xiaochen Bo, Yibo Wu and Shengqi Wang. GOSemSim: an R package for measuring semantic similarity among GO terms and gene products. *Bioinformatics* 2010 26(7):976-978.

Herve Pages, Marc Carlson, Seth Falcon and Nianhua Li (2017). AnnotationDbi: Annotation Database Interface. R package version 1.38.0.

See Also

Other GO_semantic_similarity: [GO_SS-class](#), [compute_SS_distances\(\)](#)

Examples

```
## Not run:
# initialise object for compute GO Semantic Similarity
myGOs<-ViSEAGO::build_GO_SS(
  myGENE2GO,
  BP_sResults
)

## End(Not run)
# load data example
utils::data(
  myGOs,
  package="ViSEAGO"
)
```

clusters_cor

Compute distance matrix between dendrograms partitions.

Description

Build a distance or correlation matrix between partitions from dendrograms.

Usage

```
clusters_cor(clusters, method = "adjusted.rand")
```

```
## S4 method for signature 'list,character'
clusters_cor(clusters, method = "adjusted.rand")
```

Arguments

clusters	a list of GO_clusters-class objects, from GOterms_heatmap or GOclusters_heatmap , named as character.
method	available methods ("vi", "nmi", "split.join", "rand", or "adjusted.rand") from igraph package compare function.

Value

a distance or a correlation matrix.

References

Csardi G, Nepusz T: The igraph software package for complex network research, InterJournal, Complex Systems 1695. 2006. <http://igraph.org>.

See Also

Other GO_clusters: [GO_clusters-class](#), [GOclusters_heatmap\(\)](#), [compare_clusters\(\)](#), [show_heatmap\(\)](#), [show_table\(\)](#)

Examples

```
# load example object
data(
  myGOs,
  package="ViSEAGO"
)

## Not run:
# compute Semantic Similarity (SS)
myGOs<-ViSEAGO::compute_SS_distances(
  myGOs,
  distance=c("Resnik", "Lin", "Rel", "Jiang", "Wang")
)

# Resnik distance GO terms heatmap
Resnik_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
    tree=list(
      distance="Resnik",
      aggreg.method="ward.D2"
    ),
    cut=list(
      dynamic=list(
        deepSplit=2,
        minClusterSize =2
      )
    )
  ),
  samples.tree=NULL
)

# Lin distance GO terms heatmap
Lin_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
    tree=list(
      distance="Lin",
      aggreg.method="ward.D2"
    ),
    cut=list(
      dynamic=list(
        deepSplit=2,
```

```
        minClusterSize =2
      )
    )
  ),
  samples.tree=NULL
)

# Resnik distance GO terms heatmap
Rel_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
    tree=list(
      distance="Rel",
      aggreg.method="ward.D2"
    ),
    cut=list(
      dynamic=list(
        deepSplit=2,
        minClusterSize =2
      )
    )
  ),
  samples.tree=NULL
)

# Resnik distance GO terms heatmap
Jiang_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
    tree=list(
      distance="Jiang",
      aggreg.method="ward.D2"
    ),
    cut=list(
      dynamic=list(
        deepSplit=2,
        minClusterSize =2
      )
    )
  ),
  samples.tree=NULL
)

# Resnik distance GO terms heatmap
Wang_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
```

```

    tree=list(
      distance="Wang",
      aggreg.method="ward.D2"
    ),
    cut=list(
      dynamic=list(
        deepSplit=2,
        minClusterSize =2
      )
    )
  ),
  samples.tree=NULL
)

## End(Not run)
# clusters to compare
clusters<-list(
  Resnik="Resnik_clusters_wardD2",
  Lin="Lin_clusters_wardD2",
  Rel="Rel_clusters_wardD2",
  Jiang="Jiang_clusters_wardD2",
  Wang="Wang_clusters_wardD2"
)

## Not run:
# global dendrogram clustering correlation
clust_cor<-ViSEAGO::clusters_cor(
  clusters,
  method="adjusted.rand"
)

## End(Not run)

```

compare_clusters *Heatmap to compare partitions*

Description

Build an interactive heatmap of the common GO terms frequency between several partitions.

Usage

```
compare_clusters(clusters)
```

```
## S4 method for signature 'list'
compare_clusters(clusters)
```

Arguments

clusters a list of named [GO_clusters-class](#) objects, from [GOterms_heatmap](#) or [GOclusters_heatmap](#) methods.

Details

Build an interactive heatmap of common GO terms frequency between partitions from several `GO_clusters-class` objects.

Value

an interactive javascript heatmap.

References

Carson Sievert, Chris Parmer, Toby Hocking, Scott Chamberlain, Karthik Ram, Marianne Corvellec and Pedro Despouy (2017). `plotly`: Create Interactive Web Graphics via 'plotly.js'. R package version 4.6.0. <https://CRAN.R-project.org/package=plotly>

See Also

Other `GO_clusters`: `GO_clusters-class`, `GOclusters_heatmap()`, `clusters_cor()`, `show_heatmap()`, `show_table()`

Examples

```
# load example object
data(
  myGOs,
  package="ViSEAGO"
)

## Not run:
# compute Semantic Similarity (SS)
myGOs<-ViSEAGO::compute_SS_distances(
  myGOs,
  distance=c("Resnik", "Lin", "Rel", "Jiang", "Wang")
)

# Resnik distance GO terms heatmap
Resnik_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
    tree=list(
      distance="Resnik",
      aggreg.method="ward.D2"
    ),
    cut=list(
      dynamic=list(
        deepSplit=2,
        minClusterSize =2
      )
    )
  ),
)
```

```
    samples.tree=NULL
  )

# Lin distance GO terms heatmap
Lin_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
    tree=list(
      distance="Lin",
      aggreg.method="ward.D2"
    ),
    cut=list(
      dynamic=list(
        deepSplit=2,
        minClusterSize =2
      )
    )
  ),
  samples.tree=NULL
)

# Resnik distance GO terms heatmap
Rel_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
    tree=list(
      distance="Rel",
      aggreg.method="ward.D2"
    ),
    cut=list(
      dynamic=list(
        deepSplit=2,
        minClusterSize =2
      )
    )
  ),
  samples.tree=NULL
)

# Resnik distance GO terms heatmap
Jiang_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
    tree=list(
      distance="Jiang",
      aggreg.method="ward.D2"
    ),

```

```

        cut=list(
            dynamic=list(
                deepSplit=2,
                minClusterSize =2
            )
        )
    ),
    samples.tree=NULL
)

# Resnik distance GO terms heatmap
Wang_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
    myGOs,
    showIC=TRUE,
    showGOlabels=TRUE,
    GO.tree=list(
        tree=list(
            distance="Wang",
            aggreg.method="ward.D2"
        ),
        cut=list(
            dynamic=list(
                deepSplit=2,
                minClusterSize =2
            )
        )
    ),
    samples.tree=NULL
)

## End(Not run)

# clusters to compare
clusters<-list(
    Resnik="Resnik_clusters_wardD2",
    Lin="Lin_clusters_wardD2",
    Rel="Rel_clusters_wardD2",
    Jiang="Jiang_clusters_wardD2",
    Wang="Wang_clusters_wardD2"
)

## Not run:
# clusters content comparisons
clusters_comp<-ViSEAGO::compare_clusters(clusters)

## End(Not run)

```

compute_SS_distances *Compute distance between GO terms or GO clusters based on semantic similarity.*

Description

This method computes distance between GO terms or GO clusters based on semantic similarity.

Usage

```
compute_SS_distances(object, distance)

## S4 method for signature 'ANY,character'
compute_SS_distances(object, distance)
```

Arguments

object	a GO_SS-class , or GO_clusters-class objects created by build_GO_SS or GOterms_heatmap methods, respectively.
distance	The available methods for calculating GO terms Semantic Similarity (SS) are "Resnik", "Rel", "Lin", and "Jiang" which are based on Information Content (IC), and "Wang" which is based on graph topology. The available methods for calculating clusters of GO terms SS are "max", "avg", "rcmax", and "BMA".

Details

This method computes semantic similarity distances between all GO terms provided by [GO_SS-class](#) object.

This method also computes semantic similarity distances between all GO clusters provided by [GO_clusters-class](#) object.

Semantic Similarity computations are based on [mgoSim](#) method from the **GoSemSim** package.

Value

a [GO_SS-class](#), or a [GO_clusters-class](#) object (same class as input object).

References

Marc Carlson (2017). *GO.db: A set of annotation maps describing the entire Gene Ontology*. R package version 3.4.1.

Guangchuang Yu, Fei Li, Yide Qin, Xiaochen Bo, Yibo Wu and Shengqi Wang. *GOSemSim: an R package for measuring semantic similarity among GO terms and gene products*. *Bioinformatics* 2010 26(7):976-978

Herve Pages, Marc Carlson, Seth Falcon and Nianhua Li (2017). *AnnotationDbi: Annotation Database Interface*. R package version 1.38.0.

See Also

Other `GO_semantic_similarity`: [GO_SS-class](#), [build_GO_SS\(\)](#)

Examples

```
# load data example
data(
  myGOs,
  package="ViSEAGO"
)

## Not run:
# compute GO terms Semantic Similarity distances
myGOs<-ViSEAGO::compute_SS_distances(
  myGOs,
  distance=c("Resnik","Lin","Rel","Jiang","Wang")
)

# GOtermsHeatmap with default parameters
Wang_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
    tree=list(
      distance="Wang",
      aggreg.method="ward.D2",
      rotate=NULL
    ),
    cut=list(
      dynamic=list(
        pamStage=TRUE,
        pamRespectsDendro=TRUE,
        deepSplit=2,
        minClusterSize=2
      )
    )
  ),
  samples.tree=NULL
)

# compute clusters of GO terms Semantic Similarity distances
Wang_clusters_wardD2<-ViSEAGO::compute_SS_distances(
  Wang_clusters_wardD2,
  distance=c("max","avg","rcmax","BMA")
)

## End(Not run)
```

Description

This method create a [topGOdata-class](#) object required by **topGO** package in order to perform GO enrichment test.

Usage

```
create_topGOdata(geneSel, allGenes, geneList = NULL, gene2GO, ont, nodeSize)

## S4 method for signature 'ANY,ANY,ANY,gene2GO,character,numeric'
create_topGOdata(geneSel, allGenes, geneList = NULL, gene2GO, ont, nodeSize)
```

Arguments

geneSel	genes of interest.
allGenes	customized background genes.
geneList	logical factor (1: genes of interest, 0: genes background, and gene identifiants in names) (default value to NULL).
gene2GO	a gene2GO-class object created by annotate method.
ont	the ontology used is "MF" (Molecular Function), "BP" (Biological Process), or "CC" (Cellular Component).
nodeSize	the minimum number of genes for each GO term.

Details

This method is a convenient wrapper building a [topGOdata-class](#) object using a given ontology category (ont argument) in order to perform GO enrichment test. The complete GO annotation is required (gene2GO argument) and also the list of genes of interest (geneSel argument) against the corresponding background (allGenes argument) separately, or grouped together in a factor (geneList argument).

Value

a [topGOdata-class](#) object required by runTest from **topGO** package.

References

Alexa A, Rahnenfuhrer J, Lengauer T. Improved scoring of functional groups from gene expression data by decorrelating GO graph structure. *Bioinformatics* 2006; 22:1600-1607.

See Also

Other GO_terms: [GOcount\(\)](#), [GOterms_heatmap\(\)](#), [annotate\(\)](#), [gene2GO-class](#), [merge_enrich_terms\(\)](#), [runfgsea\(\)](#)

Examples

```
# load genes identifiers (GeneID,ENS...) background (Expressed genes)
background<-scan(
  system.file(
    "extdata/data/input",
    "background_L.txt",
    package = "ViSEAGO"
  ),
  quiet=TRUE,
  what=""
)

# load Differentially Expressed (DE) gene identifiers from files
pregnantvslactateDE<-scan(
  system.file(
    "extdata/data/input",
    "pregnantvslactateDE.txt",
    package = "ViSEAGO"
  ),
  quiet=TRUE,
  what=""
)

## Not run:
# create topGOdata for BP for each list of DE genes
BP_L_pregnantvslactate<-ViSEAGO::create_topGOdata(
  geneSel=pregnantvslactateDE,
  allGenes=background,
  gene2GO=myGENE2GO,
  ont="BP",
  nodeSize=5
)

## End(Not run)
```

Custom2GO

Store organisms GO annotations from custom database file.

Description

Store the available species and current GO annotations from a custom table file

Usage

Custom2GO(file)

Arguments

file custom GO annotation file

Details

This function load a custom GO annotation database table that must contain columns:

taxid custom taxonomic identifiants

gene_id custom gene identifiants

gene_symbol custom gene symbols

GOID Known GO identifiants (see `select(GO.db, columns=columns(GO.db), keys=keys(GO.db))`)

evidence Known GO [evidence codes](#)

Value

a [genomic_ressource-class](#) object required by `annotate`.

References

Matt Dowle and Arun Srinivasan (2017). `data.table`: Extension of 'data.frame'. R package version 1.10.4. <https://CRAN.R-project.org/package=data.table>.

See Also

Other `genomic_ressource`: [Bioconductor2GO\(\)](#), [Ensembl2GO\(\)](#), [EntrezGene2GO\(\)](#), [Uniprot2GO\(\)](#), [annotate\(\)](#), [available_organisms\(\)](#), [genomic_ressource-class](#), [taxonomy\(\)](#)

Examples

```
# Download custom GO annotations
Custom<-ViSEAGO::Custom2GO(
  system.file(
    "extdata/customfile.txt",
    package = "ViSEAGO"
  )
)
```

`enrich_GO_terms-class` *enrich_GO_terms class object definition.*

Description

This class is invoked by `merge_enrich_terms` method in order to store the merged `data.table` and associated metadata.

Slots

`same_genes_background` logical. object(s) to combine (see examples in `merge_enrich_terms`).

`ont` ontology used "MF", "BP", or "CC".

`method` enrichment test used "topGO", or "fgsea".

`summary` a list with topGO or fgsea object(s) summary informations.

`data` a merged `data.table` of enriched GO terms ($p < 0.01$) in at least once with GO descriptions and statistical values.

See Also

Other enrich_GO_terms: [Upset\(\)](#), [overLapper\(\)](#), [show_heatmap\(\)](#), [show_table\(\)](#)

Ensembl2GO

Check available organisms datasets at Ensembl.

Description

List Ensembl referenced organisms datasets from the current (NULL) or archive (number in character) annotation version.

Usage

```
Ensembl2GO(biomart = "genes", GRCh = NULL, version = NULL)
```

Arguments

biomart	the biomart name available with biomaRt package listEnsembl ("genes", the default) or listEnsemblGenomes ("protists_mart", "fungi_mart", "plants_mart").
GRCh	GRCh version to connect to if not the current GRCh38, currently this can only be 37
version	the annotation version to use (eg. NULL for the default current version, or a version number in character)

Details

This function gives referenced organisms genomes at [Ensembl](#). It uses the [useEnsembl](#) and [listDatasets](#) from **biomaRt** package.

Value

a [genomic_ressource-class](#) object required by [annotate](#).

References

Durinck S, Spellman P, Birney E and Huber W (2009). Mapping identifiers for the integration of genomic datasets with the R/Bioconductor package biomaRt. *Nature Protocols*, 4, pp. 1184-1191.

Durinck S, Moreau Y, Kasprzyk A, Davis S, De Moor B, Brazma A and Huber W (2005). BioMart and Bioconductor: a powerful link between biological databases and microarray data analysis. *Bioinformatics*, 21, pp. 3439-3440.

Matt Dowle and Arun Srinivasan (2017). data.table: Extension of data.frame. R package version 1.10.4. <https://CRAN.R-project.org/package=data.table>.

See Also

Other genomic_ressource: [Bioconductor2GO\(\)](#), [Custom2GO\(\)](#), [EntrezGene2GO\(\)](#), [Uniprot2GO\(\)](#), [annotate\(\)](#), [available_organisms\(\)](#), [genomic_ressource-class](#), [taxonomy\(\)](#)

Examples

```
## Not run:
# check the Ensembl available biomaRt (if not known)
biomaRt::listEnsembl()

# List Ensembl available organisms
Ensembl<-ViSEAGO::Ensembl2GO(
  biomaRt="genes",
  GRCh = NULL,
  version=NULL
)

## End(Not run)
```

EntrezGene2GO

Store available organisms GO annotations at EntrezGene.

Description

Store the available species and current GO annotations from the [gene2go.gz](#) nfile available at NCBI [EntrezGene ftp](#).

Usage

```
EntrezGene2GO()
```

Details

This function downloads the [gene2go.gz](#) file from [EntrezGene ftp](#) which contains available organisms (taxid) with the corresponding GO annotations.

Value

a [genomic_ressource-class](#) object required by [annotate](#).

References

- Matt Dowle and Arun Srinivasan (2017). data.table: Extension of ‘data.frame’. R package version 1.10.4. <https://CRAN.R-project.org/package=data.table>.
- Eric Sayers (2013). Entrez Programming Utilities Help.
- #’ Henrik Bengtsson (2016). R.utils: Various Programming Utilities. R package version 2.5.0. <https://CRAN.R-project.org/package=R.utils>.
- Maglott, D, Ostell, J, Pruitt, KD, Tatusova, T (2011). Entrez Gene: gene-centered information at NCBI. Nucleic Acids Res., 39, Database issue:D52-7.

See Also

Other genomic_ressource: [Bioconductor2G0\(\)](#), [Custom2G0\(\)](#), [Ensembl2G0\(\)](#), [Uniprot2G0\(\)](#), [annotate\(\)](#), [available_organisms\(\)](#), [genomic_ressource-class](#), [taxonomy\(\)](#)

Examples

```
## Not run:  
# Download EntrezGene available organisms GO annotations  
EntrezGene<-ViSEAG0::EntrezGene2G0()  
  
## End(Not run)
```

EntrezGene_orthologs *Download EntrezGene orthologs groups.*

Description

Download EntrezGene orthologs groups.

Usage

```
EntrezGene_orthologs()
```

Details

Internal function used by [annotate](#) in order to download orthologs_groups from NCBI Annotation pipeline stored in the [gene_group.gz](#) file.

Value

a [data.table](#).

Examples

```
## Not run:  
# Organism taxid, Scientific name and common name  
ViSEAG0::EntrezGene_orthologs()  
  
## End(Not run)
```

fgsea-class *fgsea class object definition.*

Description

This class is invoked by [runfgsea](#) method in order to store results.

Slots

description a character string with database source, date of stamp, and target species GO annotation.

method fgsea method used.

params a list containing used input parameters for perform [fgseaSimple](#) or [fgseaMultilevel](#).

input a list containing input values.

data a list containing data. table fgsea procedure output.

gene2GO-class *gene2GO class object definition.*

Description

This class is invoked by [annotate](#) method in order to store GO annotations for each category (MF, BP, CC).

Slots

db database source in character.

stamp date of stamp in character.

organism target species GO annotation in character.

MF a list containing GO terms for Molecular Function (MF) category for each gene element.

BP a list containing GO terms for Biological Process (BP) category for each gene element.

CC a list containing GO terms for Cellular Component (CC) category for each gene element.

See Also

Other GO_terms: [GOcount\(\)](#), [GOterms_heatmap\(\)](#), [annotate\(\)](#), [create_topGOdata\(\)](#), [merge_enrich_terms\(\)](#), [runfgsea\(\)](#)

 genomic_ressource-class

genomic_ressource class object definition.

Description

This class stores the annotations and associated metadata obtained by [Bioconductor2GO](#), [EntrezGene2GO](#), [Ensembl2GO](#), or [Uniprot2GO](#).

Slots

db name of database used (Bioconductor, EntrezGene, Ensembl, or Uniprot).
 stamp date of stamp (for Bioconductor, EntrezGene, and Uniprot), or annotation version for Ensembl database.
 data GO annotations from [EntrezGene2GO](#) method.
 organisms informations about species/datasets availables.
 mart Ensembl mart from [Ensembl2GO](#) method.

See Also

Other genomic_ressource: [Bioconductor2GO\(\)](#), [Custom2GO\(\)](#), [Ensembl2GO\(\)](#), [EntrezGene2GO\(\)](#), [Uniprot2GO\(\)](#), [annotate\(\)](#), [available_organisms\(\)](#), [taxonomy\(\)](#)

 GOclusters_heatmap *Build a clustering heatmap on GO groups.*

Description

This method computes a clustering heatmap based on GO groups semantic similarity.

Usage

```
GOclusters_heatmap(
  object,
  tree = list(distance = "BMA", aggreg.method = "ward.D2", rotate = NULL)
)

## S4 method for signature 'GO_clusters,list'
GOclusters_heatmap(
  object,
  tree = list(distance = "BMA", aggreg.method = "ward.D2", rotate = NULL)
)
```

Arguments

- object** a `GO_clusters-class` object from `compute_SS_distances`.
- tree** a named list with:
- distance ("BMA" by default)** distance computed from the semantic similarity for GO groups which could be "max", "avg", "rcmax", or "BMA".
 - aggreg.method ("ward.D2" by default)** aggregation method criteria from `hclust` ("ward.D", "ward.D2", "single", "complete", "average", "mcquitty", "median", or "centroid") to build a dendrogram.
 - rotate** sort the branches of the tree based on a vector - either of labels order or the labels in their new order

Details

This method computes a clustering heatmap based on GO groups semantic similarity (computed with `compute_SS_distances`).

The heatmap color intensity corresponds to the number of GO terms in each GO group.

GO group description is defined as the first common GO ancestor with the cluster identifier in brackets.

The dendrogram branches are colored according to GO terms clusters.

Value

a `GO_clusters-class` object.

References

Matt Dowle and Arun Srinivasan (2017). `data.table`: Extension of 'data.frame'. R package version 1.10.4. <https://CRAN.R-project.org/package=data.table>.

Tal Galili (2015). `dendextend`: an R package for visualizing, adjusting, and comparing trees of hierarchical clustering. *Bioinformatics*. DOI:10.1093/bioinformatics/btv428.

Tal Galili (2017). `heatmaply`: Interactive Cluster Heat Maps Using 'plotly'. R package version 0.9.1. <https://CRAN.R-project.org/package=heatmaply>.

Erich Neuwirth (2014). `RColorBrewer`: ColorBrewer Palettes. R package version 1.1-2. <https://CRAN.R-project.org/package=RColorBrewer>.

Carson Sievert, Chris Parmer, Toby Hocking, Scott Chamberlain, Karthik Ram, Marianne Corvellec and Pedro Despouy (2017). `plotly`: Create Interactive Web Graphics via 'plotly.js'. R package version 4.6.0. <https://CRAN.R-project.org/package=plotly>.

H. Wickham. `ggplot2`: Elegant Graphics for Data Analysis. Springer-Verlag New York, 2009.

See Also

Other `GO_clusters`: `GO_clusters-class`, `clusters_cor()`, `compare_clusters()`, `show_heatmap()`, `show_table()`

Other semantic_similarity: `G0terms_heatmap()`

Other visualization: `G0count()`, `G0terms_heatmap()`, `Upset()`, `available_organisms()`, `overLapper()`, `show_heatmap()`, `show_table()`

Examples

```
# load data example
utils::data(
  myGOs,
  package="ViSEAGO"
)
## Not run:
# compute GO terms Semantic Similarity distances
myGOs<-ViSEAGO::compute_SS_distances(
  myGOs,
  distance="Wang"
)

# GOtermsHeatmap with default parameters
Wang_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
    tree=list(
      distance="Wang",
      aggreg.method="ward.D2",
      rotate=NULL
    ),
    cut=list(
      dynamic=list(
        pamStage=TRUE,
        pamRespectsDendro=TRUE,
        deepSplit=2,
        minClusterSize =2
      )
    )
  ),
  samples.tree=NULL
)

# compute clusters of GO terms Semantic Similarity distances
Wang_clusters_wardD2<-ViSEAGO::compute_SS_distances(
  Wang_clusters_wardD2,
  distance="BMA"
)

# GOclusters heatmap
Wang_clusters_wardD2<-ViSEAGO::GOclusters_heatmap(
  Wang_clusters_wardD2,
  tree=list(
    distance="BMA",
    aggreg.method="ward.D2",
    rotate=NULL
  )
)
```

```
## End(Not run)
```

GOcount	<i>Barplot for the count of GO terms.</i>
---------	-------------------------------------------

Description

This method displays in barplot the count of GO terms splitted in two categories (significant or not) for each result of GO enrichment tests.

Usage

```
GOcount(object, file = NULL)

## S4 method for signature 'ANY'
GOcount(object, file = NULL)
```

Arguments

object	an enrich_GO_terms-class object from merge_enrich_terms method.
file	the name of the output file (default to NULL for interactive screen display).

Details

This method displays an interactive barplot, using **plotly** package, from a [merge_enrich_terms](#) output object.
A static image (in png) could be printed by setting file argument.

Value

a barplot.

References

Carson Sievert, Chris Parmer, Toby Hocking, Scott Chamberlain, Karthik Ram, Marianne Corvellec and Pedro Despouy (2017). `plotly: Create InteractiveWeb Graphics via 'plotly.js'`. R package version 4.6.0. <https://CRAN.R-project.org/package=plotly>.

See Also

Other GO_terms: [GOterms_heatmap\(\)](#), [annotate\(\)](#), [create_topGOdata\(\)](#), [gene2GO-class](#), [merge_enrich_terms\(\)](#), [runfgsea\(\)](#)

Other visualization: [GOclusters_heatmap\(\)](#), [GOterms_heatmap\(\)](#), [Upset\(\)](#), [available_organisms\(\)](#), [overLapper\(\)](#), [show_heatmap\(\)](#), [show_table\(\)](#)

Examples

```
# load object
utils::data(
  myGOs,
  package="ViSEAGO"
)

# barplot for the count of GO terms
ViSEAGO::GOcount( myGOs)
```

GOterms_heatmap	<i>Build a clustering heatmap on GO terms.</i>
-----------------	------------------------------------------------

Description

This method computes a clustering heatmap based on GO terms semantic similarity.

Usage

```
GOterms_heatmap(
  myGOs,
  showIC = TRUE,
  showGOlabels = TRUE,
  heatmap_colors = c("#ffffff", "#99000D"),
  GO.tree = list(tree = list(distance = "Wang", aggreg.method = "ward.D2", rotate =
    NULL), cut = list(dynamic = list(pamStage = TRUE, pamRespectsDendro = TRUE, deepSplit
    = 2, minClusterSize = 2))),
  samples.tree = NULL
)

## S4 method for signature 'GO_SS'
GOterms_heatmap(
  myGOs,
  showIC = TRUE,
  showGOlabels = TRUE,
  heatmap_colors = c("#ffffff", "#99000D"),
  GO.tree = list(tree = list(distance = "Wang", aggreg.method = "ward.D2", rotate =
    NULL), cut = list(dynamic = list(pamStage = TRUE, pamRespectsDendro = TRUE, deepSplit
    = 2, minClusterSize = 2))),
  samples.tree = NULL
)
```

Arguments

myGOs	a GO_SS-class object from compute_SS_distances .
showIC	logical (default to TRUE) to display the GO terms Information Content (IC) side bar.

showGOlabels	logical (default to TRUE) to display the GO terms ticks on y axis.
heatmap_colors	pvalues color range with white to Sangria collors by default (c("#ffffff", "#99000D")).
GO.tree	a named list of parameters to build and cut the GO terms dendrogram. tree (a named list with:) distance ("Wang" by default) distance computed from the semantic similarity which could be IC-based ("Resnik", "Rel", "Lin", or "Jiang") or graph-based ("Wang"). aggreg.method ("ward.D2" by default) aggregation method criteria from hclust ("ward.D", "ward.D2", "single", "complete", "average", "mcquitty", "median", or "centroid") to build a dendrogram. rotate sort the branches of the tree based on a vector - either of labels order or the labels in their new order cut (a named list with:) static (default to NULL) a numeric value that is the height (between 0 and 1), or the number of clusters (value > 1) to cut the dendrogram. dynamic (a named list which only contains cuttreeDynamic options values below) pamStage second (PAM-like) stage will be performed. pamRespectsDendro (default to TRUE) PAM stage will respect the dendrogram in the sense that objects and small clusters will only be assigned to clusters that belong to the same branch that the objects or small clusters being assigned belong to. deepSplit (default to 2) provides a rough control over sensitivity for cluster splitting (range 0 to 4). The higher the value (or if TRUE), the more and smaller clusters will be produced. minClusterSize (default to 2) minimum cluster size.
samples.tree	a named list of parameters to build and cut the samples dendrogram (default to NULL). tree (a named list with:) distance ("pearson" by default) distance computed that could be correlation ("abs.pearson", "pearson", "kendall", or "spearman"), or dist method (euclidean, "maximum", "manhattan", "canberra", "binary", or "minkowski). aggreg.method ("average" by default) same options than for GO.tree argument cut same options than for GO.tree argument.

Details

This method computes a clustering heatmap based on GO terms semantic similarity (computed with [compute_SS_distances](#)).

The dendrogram produced could be cutted in static or dynamic mode.

1. build dendrograms on GO terms and optionally on samples.
2. cut in static or dynamic mode and color the dendrogram branches.
3. build an interactive clustering heatmap based on [heatmaply](#).

Value

a `GO_clusters-class` object.

References

Matt Dowle and Arun Srinivasan (2017). `data.table`: Extension of ‘`data.frame`’. R package version 1.10.4. <https://CRAN.R-project.org/package=data.table>.

Tal Galili (2015). `dendextend`: an R package for visualizing, adjusting, and comparing trees of hierarchical clustering. *Bioinformatics*. DOI:10.1093/bioinformatics/btv428.

Tal Galili (2017). `heatmaply`: Interactive Cluster Heat Maps Using ‘`plotly`’. R package version 0.9.1. <https://CRAN.R-project.org/package=heatmaply>.

Peter Langfelder, Bin Zhang and with contributions from Steve Horvath (2016). `dynamicTreeCut`: Methods for Detection of Clusters in Hierarchical Clustering Dendrograms. R package version 1.63-1. <https://CRAN.R-project.org/package=dynamicTreeCut>.

Erich Neuwirth (2014). `RColorBrewer`: ColorBrewer Palettes. R package version 1.1-2. <https://CRAN.R-project.org/package=RColorBrewer>.

Carson Sievert, Chris Parmer, Toby Hocking, Scott Chamberlain, Karthik Ram, Marianne Corvellec and Pedro Despouy (2017). `plotly`: Create Interactive Web Graphics via ‘`plotly.js`’. R package version 4.6.0. <https://CRAN.R-project.org/package=plotly>.

Hadley Wickham (2016). `scales`: Scale Functions for Visualization. R package version 0.4.1. <https://CRAN.R-project.org/package=scales>.

H. Wickham. `ggplot2`: Elegant Graphics for Data Analysis. Springer-Verlag New York, 2009.

See Also

Other `GO_terms`: `GOcount()`, `annotate()`, `create_topGOdata()`, `gene2GO-class`, `merge_enrich_terms()`, `runfgsea()`

Other `semantic_similarity`: `GOclusters_heatmap()`

Other `visualization`: `GOclusters_heatmap()`, `GOcount()`, `Upset()`, `available_organisms()`, `overLapper()`, `show_heatmap()`, `show_table()`

Examples

```
# load data example
utils::data(
  myGOs,
  package="ViSEAGO"
)
## Not run:
# compute GO terms Semantic Similarity distances
myGOs<-ViSEAGO::compute_SS_distances(
  myGOs,
  distance="Wang"
)

# GOtermsHeatmap with default parameters
Wang_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
```

```

myGOs,
showIC=TRUE,
showGOlabels=TRUE,
GO.tree=list(
  tree=list(
    distance="Wang",
    aggreg.method="ward.D2",
    rotate=NULL
  ),
  cut=list(
    dynamic=list(
      pamStage=TRUE,
      pamRespectsDendro=TRUE,
      deepSplit=2,
      minClusterSize =2
    )
  )
),
samples.tree=NULL
)

## End(Not run)

```

GO_clusters-class *GO_clusters class object*

Description

This class is invoked by [GOterms_heatmap](#) and [GOclusters_heatmap](#) methods to store all results produced.

Slots

ont ontology used "MF", "BP", or "CC".
 enrich_GOs [enrich_GO_terms-class](#) object.
 IC Information Content (IC).
 terms_dist distance between GO terms based on semantic similarity.
 clusters_dist distance between GO groups based on semantic similarity.
 hcl_params Hierarchical clustering parameters used.
 dendrograms GO terms and samples dendrograms.
 samples_gp samples groups.
 heatmap GO terms and GO groups heatmaps.

See Also

Other GO_clusters: [GOclusters_heatmap\(\)](#), [clusters_cor\(\)](#), [compare_clusters\(\)](#), [show_heatmap\(\)](#), [show_table\(\)](#)

GO_SS-class	<i>GO_SS class object definition.</i>
-------------	---------------------------------------

Description

This class is invoked by `build_GO_SS` method in order to store `enrich_GO_terms-class` object, Information Content (IC), and GO terms or groups distances objects based on semantic similarity.

Slots

`ont` ontology used "MF", "BP", or "CC".

`enrich_GOs` `merge_enrich_terms` output object (`enrich_GO_terms-class` object).

`IC` Information Content (IC)

`terms_dist` list of GO terms or groups distances objects based on semantic similarity.

See Also

Other `GO_semantic_similarity`: `build_GO_SS()`, `compute_SS_distances()`

MDSplot	<i>Multi Dimensional Scale (MDS) plot</i>
---------	-------------------------------------------

Description

Generate a Multi Dimensional Scale (MDS) plot from distance objects.

Usage

```
MDSplot(object, type = "GOTerms", file = NULL)
```

```
## S4 method for signature 'ANY'
```

```
MDSplot(object, type = "GOTerms", file = NULL)
```

Arguments

`object` a `GO_SS-class` or `GO_clusters-class` objects from distances computed with `compute_SS_distances`.

`type` could be "GOTerms" to display GOTerms MDSplot, or "GOclusters" to display GOclusters MDSplot.

`file` static image output file name (default to NULL).

Details

This method build and display the javascript MDSplot (if `file=NULL`) from `GO_SS-class` or `GO_clusters-class` objects.

A static png image could be printed by setting file argument.

Value

a MDS plot.

Examples

```

# load data example
utils::data(
  myGOs,
  package="ViSEAGO"
)
## Not run:
# compute GO terms Semantic Similarity distances
myGOs<-ViSEAGO::compute_SS_distances(
  myGOs,
  distance="Wang"
)

# build MDS plot for a GO_SS-class distance object
ViSEAGO::MDSplot(myGOs,"GOterms")

# GOtermsHeatmap with default parameters
Wang_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
    tree=list(
      distance="Wang",
      aggreg.method="ward.D2",
      rotate=NULL
    ),
    cut=list(
      dynamic=list(
        pamStage=TRUE,
        pamRespectsDendro=TRUE,
        deepSplit=2,
        minClusterSize =2
      )
    )
  ),
  samples.tree=NULL
)

# build MDS plot for a GO_clusters-class distance object, highlighting GO terms clusters.
ViSEAGO::MDSplot(
  Wang_clusters_wardD2,
  "GOterms"
)

# compute clusters of GO terms Semantic Similarity distances
Wang_clusters_wardD2<-ViSEAGO::compute_SS_distances(
  Wang_clusters_wardD2,

```

```

    distance="BMA"
  )

  # GOclusters heatmap
  Wang_clusters_wardD2<-ViSEAGO::GOclusters_heatmap(
    Wang_clusters_wardD2,
    tree=list(
      distance="BMA",
      aggreg.method="ward.D2",
      rotate=NULL
    )
  )

  # build MDS plot for a GO_clusters-class distance object, highlighting GO groups clusters.
  ViSEAGO::MDSplot(
    Wang_clusters_wardD2,
    "GOclusters"
  )

  ## End(Not run)

```

merge_enrich_terms *Merge enriched GO terms.*

Description

combine results from GO enrichment tests (obtained with **topGO** package) or from **fgsea** (obtained with [runfgsea](#) method), for a given ontology (MF, BP, or CC).

Usage

```

merge_enrich_terms(Input, cutoff = 0.01, envir = .GlobalEnv)

## S4 method for signature 'list'
merge_enrich_terms(Input, cutoff = 0.01, envir = .GlobalEnv)

```

Arguments

Input	a list containing named elements. Each element must contain the name of: <ul style="list-style-type: none"> • topGO: topGOdata-class object created by create_topGOdata method and the associated topGOresult-class object. • fgsea: fgsea-class object created by runfgsea method.
cutoff	default pvalue cutoff (default to 0.01). Several cutoff can be use in the same order as list elements.
envir	objects environment (default to .GlobalEnv).

Details

This method extracts for each result of GO enrichment test: informations about GO term (identifiant, name, and description), gene frequency (number of significant genes / Annotated genes), pvalue, $-\log_{10}(\text{pvalue})$, significant genes identifiants (GeneID, or Ensembl ID, or uniprot accession), and gene symbols. At the last, this method builds a merged data.table of enriched GO terms at least once and provides all mentioned columns.

Value

an `enrich_GO_terms-class` object.

References

Matt Dowle and Arun Srinivasan (2017). `data.table`: Extension of `data.frame`. R package version 1.10.4. <https://CRAN.R-project.org/package=data.table>

Herve Pages, Marc Carlson, Seth Falcon and Nianhua Li (2017). `AnnotationDbi`: Annotation Database Interface. R package version 1.38.0.

See Also

Other `GO_terms`: `GOcount()`, `GOterms_heatmap()`, `annotate()`, `create_topGOdata()`, `gene2GO-class`, `runfgsea()`

Examples

```
## topGO terms enrichment

# load genes identifiants (GeneID,ENS...) universe/background (Expressed genes)
background_L<-scan(
  system.file(
    "extdata/data/input",
    "background_L.txt",
    package = "ViSEAGO"
  ),
  quiet=TRUE,
  what=""
)

# load Differentially Expressed (DE) gene identifiants from files
PregnantvslactateDE<-scan(
  system.file(
    "extdata/data/input",
    "pregnantvslactateDE.txt",
    package = "ViSEAGO"
  ),
  quiet=TRUE,
  what=""
)

VirginvslactateDE<-scan(
  system.file(
```

```
        "extdata/data/input",
        "virginvslactateDE.txt",
        package = "ViSEAGO"
    ),
    quiet=TRUE,
    what=""
)

VirginvsPregnantDE<-scan(
  system.file(
    "extdata/data/input",
    "virginvsPregnantDE.txt",
    package="ViSEAGO"
  ),
  quiet=TRUE,
  what=""
)

## Not run:
# connect to Bioconductor
Bioconductor<-ViSEAGO::Bioconductor2GO()

# load GO annotations from Bioconductor
myGENE2GO<-ViSEAGO::annotate(
  "org.Mm.eg.db",
  Bioconductor
)

# create topGOdata for BP for each list of DE genes
BP_Pregnantvslactate<-ViSEAGO::create_topGOdata(
  geneSel=PregnantvslactateDE,
  allGenes=background_L,
  gene2GO=myGENE2GO,
  ont="BP",
  nodeSize=5
)

BP_Virginvslactate<-ViSEAGO::create_topGOdata(
  geneSel=VirginvslactateDE,
  allGenes=background_L,
  gene2GO=myGENE2GO,
  ont="BP",
  nodeSize=5
)

BP_VirginvsPregnant<-ViSEAGO::create_topGOdata(
  geneSel=VirginvsPregnantDE,
  allGenes=background_L,
  gene2GO=myGENE2GO,
  ont="BP",
  nodeSize=5
)
```

```
# perform TopGO tests
elim_BP_Pregnantvslactate<-topGO::runTest(
  BP_L_pregnantvslactate,
  algorithm ="elim",
  statistic = "fisher"
)

elim_BP_Virginvslactate<-topGO::runTest(
  BP_L_virginvslactate,
  algorithm ="elim",
  statistic = "fisher"
)

elim_BP_VirginvsPregnant<-topGO::runTest(
  BP_L_virginvsPregnant,
  algorithm ="elim",
  statistic = "fisher"
)

# merge topGO results
BP_sResults<-ViSEAGO::merge_enrich_terms(
  Input=list(
    Pregnantvslactate=c("BP_Pregnantvslactate","elim_BP_Pregnantvslactate"),
    Virginvslactate=c("BP_Virginvslactate","elim_BP_Virginvslactate"),
    VirginvsPregnant=c("BP_VirginvsPregnant","elim_BP_VirginvsPregnant")
  )
)

## End(Not run)

## fgsea analysis

# load gene identifiers and padj test results from Differential Analysis complete tables
Pregnantvslactate<-data.table::fread(
  system.file(
    "extdata/data/input",
    "pregnantvslactate.complete.txt",
    package = "ViSEAGO"
  ),
  select = c("Id","padj")
)

Virginvslactate<-data.table::fread(
  system.file(
    "extdata/data/input",
    "virginvslactate.complete.txt",
    package = "ViSEAGO"
  ),
  select = c("Id","padj")
)

VirginvsPregnant<-data.table::fread(
  system.file(
```

```
        "extdata/data/input",
        "virginvsPregnant.complete.txt",
        package = "ViSEAGO"
    ),
    select = c("Id", "padj")
)

# rank Id based on statistical value (padj)
PregnantvsLactate<-data.table::setorder(PregnantvsLactate,padj)

VirginvsLactate<-data.table::setorder(VirginvsLactate,padj)

VirginvsPregnant<-data.table::setorder(VirginvsPregnant,padj)

## Not run:
# connect to Bioconductor
Bioconductor<-ViSEAGO::Bioconductor2GO()

# load GO annotations from Bioconductor
myGENE2GO<-ViSEAGO::annotate(
  "org.Mm.eg.db",
  Bioconductor
)

# perform fgseaMultilevel tests
BP_PregnantvsLactate<-runfgsea(
  geneSel=PregnantvsLactate,
  gene2GO=myGENE2GO,
  ont="BP",
  params = list(
    scoreType = "pos",
    minSize=5
  )
)

BP_VirginvsLactate<-runfgsea(
  geneSel=VirginvsLactate,
  gene2GO=myGENE2GO,
  ont="BP",
  params = list(
    scoreType = "pos",
    minSize=5
  )
)

BP_VirginvsPregnant<-runfgsea(
  geneSel=VirginvsPregnant,
  gene2GO=myGENE2GO,
  ont="BP",
  params = list(
    scoreType = "pos",
    minSize=5
  )
)
```

```

)

# merge fgsea results
BP_sResults<-merge_enrich_terms(
  cutoff=0.01,
  Input=list(
    PregnantvsLactate="BP_PregnantvsLactate",
    VirginvsLactate="BP_VirginvsLactate",
    VirginvsPregnant="BP_VirginvsPregnant"
  )
)

## End(Not run)

```

myGOs

myGOs dataset

Description

an example of object returned by [build_GO_SS](#) method from mouse functional analysis of mouse mammary gland RNA-Seq (2_mouse_bioconductor vignette)

Usage

```
data(myGOs, package="ViSEAGO")
```

Format

An object of class [GO_SS-class](#).

overLapper

build all sets combinations intersections

Description

build all sets combinations intersections

Usage

```
overLapper(setlist)
```

Details

This internal function use build all sets combinations intersections needed for [upset](#).

Value

a [list](#).

See Also

Other enrich_GO_terms: [Upset\(\)](#), [enrich_GO_terms-class](#), [show_heatmap\(\)](#), [show_table\(\)](#)

Other visualization: [GOclusters_heatmap\(\)](#), [GOcount\(\)](#), [GOterms_heatmap\(\)](#), [Upset\(\)](#), [available_organisms\(\)](#), [show_heatmap\(\)](#), [show_table\(\)](#)

Examples

```
## Not run:  
# build all intersections combinations  
ViSEAGO::overLapper(setlist)  
  
## End(Not run)
```

pkgdiagram

Display the ViSEAGO package diagram.

Description

This function build the ViSEAGO package diagram available displayed in the vignette.

Usage

```
pkgdiagram(x = c("white", "white", "white", "white", "white"))
```

Arguments

x rectangles colors for the five subgraphs with all white by defaults

Details

This function use **DiagrammeR** package [grViz](#) to display the ViSEAGO methods diagram with colored or not subgraphs rectangles.

Value

an html diagram

References

Knut Sveidqvist, Mike Bostock, Chris Pettitt, Mike Daines, Andrei Kashcha and Richard Iannone (2017). DiagrammeR: Create Graph Diagrams and Flowcharts Using R. R package version 0.9.0. <https://CRAN.R-project.org/package=DiagrammeR>.

Examples

```

# print diagram without focus
ViSEAGO::pkgdiagram(x=c("white","white","white","white","white"))

# print diagram with focus one the gene list
ViSEAGO::pkgdiagram(x=c("black","white","white","white","white"))

# print diagram with a focus on the annotation step
ViSEAGO::pkgdiagram(x=c("white","black","white","white","white"))

# print diagram with a focus on the enrichment step
ViSEAGO::pkgdiagram(x=c("white","white","black","white","white"))

# print diagram with a focus on the Semantic Similarity step
ViSEAGO::pkgdiagram(x=c("white","white","white","black","white"))

# print diagram with focus on the visualization step
ViSEAGO::pkgdiagram(x=c("white","white","white","white","black"))

```

runfgsea

perform multilevel preranked gene set enrichment analysis.

Description

This method perform fast gene set enrichment analysis (GSEA) using **fgsea** package.

Usage

```

runfgsea(
  geneSel,
  gene2GO,
  ont,
  method = c("fgseaSimple", "fgseaMultilevel"),
  params = list(nperm = 10000, sampleSize = 101, minSize = 1, maxSize = Inf, eps = 0,
    scoreType = c("std", "pos", "neg"), nproc = 0, gseaParam = 1, BPPARAM = NULL, absEps
    = NULL)
)

## S4 method for signature 'ANY, gene2GO, character'
runfgsea(
  geneSel,
  gene2GO,
  ont,
  method = c("fgseaSimple", "fgseaMultilevel"),
  params = list(nperm = 10000, sampleSize = 101, minSize = 1, maxSize = Inf, eps = 0,
    scoreType = c("std", "pos", "neg"), nproc = 0, gseaParam = 1, BPPARAM = NULL, absEps
    = NULL)
)

```

Arguments

geneSel	a 2 columns data.table with preranked gene identifiers (in first column) based on the statistical values (second column).
gene2GO	a gene2GO-class object created by annotate method.
ont	the ontology used is "MF" (Molecular Function), "BP" (Biological Process), or "CC" (Cellular Component).
method	fgsea method to use with fgseaSimple or fgseaMultilevel .
params	a list with fgseaSimple or fgseaMultilevel parameters.

Details

This method is a convenient wrapper using a given ontology category (ont argument) in order to perform gene set enrichment analysis using **fgseaSimple** or **fgseaMultilevel** algorithm from **fgsea** package.

The complete GO annotation is required (gene2GO argument), and also a 2 columns data.table with **preranked** gene identifiers (in first column) based on statistical values (second column).

Defaults fgseaSimple parameters were used for perform test with nperm set to 10,000.

Defaults fgseaMultilevel parameters were used for perform test except the eps arg that was set to 0 for better pvalues estimation.

A gene frequency (%) of leadingEdge/size is added to output data.table.

Value

a **fgsea-class** object.

References

Korotkevich G, Sukhov V, Sergushichev A (2019). "Fast gene set enrichment analysis." bioRxiv. doi: 10.1101/060012, <http://biorxiv.org/content/early/2016/06/20/060012>.

See Also

Other GO_terms: **GOcount()**, **GOterms_heatmap()**, **annotate()**, **create_topGOdata()**, **gene2GO-class**, **merge_enrich_terms()**

Examples

```
# gene list
PregnantvsLactate<-data.table::fread(
  system.file(
    "extdata/data/input",
    "pregnantvslactate.complete.txt",
    package = "ViSEAGO"
  ),
  select = c("Id","padj")
)

# rank Id based on statistical value (padj here)
```

```

PregnantvsLactate<-data.table::setorder(PregnantvsLactate,padj)

## Not run:
# connect to Bioconductor
Bioconductor<-ViSEAGO::Bioconductor2GO()

myGENE2GO<-ViSEAGO::annotate(
  "org.Mm.eg.db",
  Bioconductor
)

# run fgseaMultilevel
pregnantvslactate<-ViSEAGO::runfgsea(
  geneSel=PregnantvsLactate,
  gene2GO=myGENE2GO,
  ont="BP",
  method="fgseaMultilevel",
  params=list(
    minSize=5,
    scoreType="pos"
  )
)

## End(Not run)

```

show_heatmap

Display an interactive or static heatmap.

Description

Display a heatmap in interactive or static mode.

Usage

```
show_heatmap(object, type, file = NULL, plotly_update = FALSE)
```

```
## S4 method for signature 'GO_clusters,character'
show_heatmap(object, type, file = NULL, plotly_update = FALSE)
```

Arguments

object	a GO_clusters-class object from GOterms_heatmap or GOclusters_heatmap .
type	could be "GOterms" to display GOterms clustering heatmap, or "GOclusters" to display GOclusters heatmap.
file	static image output file name (default to NULL).
plotly_update	update plotly html dependencies (default to FALSE).

Details

This method displays an interactive heatmap (if file=NULL) from `GO_clusters-class` object for "GOterms" or "GOclusters" type.

A static png image could be printed by setting file argument.

Interactive heatmap cannot be displayed between two R versions. Then interactive view (build with previous R version) can be updated to new R version using `plotly_update` argument setting to TRUE.

Value

display or print heatmap.

See Also

Other `enrich_GO_terms`: `Upset()`, `enrich_GO_terms-class`, `overLapper()`, `show_table()`

Other `GO_clusters`: `GO_clusters-class`, `GOclusters_heatmap()`, `clusters_cor()`, `compare_clusters()`, `show_table()`

Other visualization: `GOclusters_heatmap()`, `GOcount()`, `GOterms_heatmap()`, `Upset()`, `available_organisms()`, `overLapper()`, `show_table()`

Examples

```
# load data example
data(
  myGOs,
  package="ViSEAGO"
)
## Not run:
# compute GO terms Semantic Similarity distances
myGOs<-ViSEAGO::compute_SS_distances(
  myGOs,
  distance="Wang"
)

# build MDS plot for a GO_SS-class distance object
ViSEAGO::MDSplot(myGOs)

# GOtermsHeatmap with default parameters
Wang_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
    tree=list(
      distance="Wang",
      aggreg.method="ward.D2",
      rotate=NULL
    ),
    cut=list(
      dynamic=list(
```

```
        pamStage=TRUE,
        pamRespectsDendro=TRUE,
        deepSplit=2,
        minClusterSize =2
    )
)
),
samples.tree=NULL
)

# Display GO terms heatmap
ViSEAGO::show_heatmap(
  Wang_clusters_wardD2,
  "GOterms"
)

# Print GO terms heatmap
ViSEAGO::show_heatmap(
  Wang_clusters_wardD2,
  "GOterms",
  "GOterms_heatmap.png"
)

# compute clusters of GO terms Semantic Similarity distances
Wang_clusters_wardD2<-ViSEAGO::compute_SS_distances(
  Wang_clusters_wardD2,
  distance="BMA"
)

# GOclusters heatmap
Wang_clusters_wardD2<-ViSEAGO::GOclusters_heatmap(
  Wang_clusters_wardD2,
  tree=list(
    distance="BMA",
    aggreg.method="ward.D2",
    rotate=NULL
  )
)

# Display GO clusters heatmap
ViSEAGO::show_heatmap(
  Wang_clusters_wardD2,
  "GOclusters"
)

# Print GO clusters heatmap
ViSEAGO::show_heatmap(
  Wang_clusters_wardD2,
  "GOclusters",
  "GOclusters_heatmap.png"
)

## End(Not run)
```

show_table	<i>Display an interactive or static table.</i>
------------	------------------------------------------------

Description

This method is used to display or print the table for `enrich_GO_terms-class` or `GO_clusters-class` objects.

Usage

```
show_table(object, file = NULL)
```

```
## S4 method for signature 'ANY'  
show_table(object, file = NULL)
```

Arguments

object	an <code>enrich_GO_terms-class</code> object from <code>merge_enrich_terms</code> , or <code>GO_clusters-class</code> object from <code>GOTerms_heatmap</code> .
file	table output file name (default to NULL).

Details

This method displays an interactive table (if file=NULL) from `enrich_GO_terms-class` or `GO_clusters-class` objects.

The table could be printed by setting file argument.

Value

display or print table

References

Yihui Xie (2016). DT: A Wrapper of the JavaScript Library 'DataTables'. R package version 0.2.
<https://CRAN.R-project.org/package=DT>

See Also

Other `enrich_GO_terms`: `Upset()`, `enrich_GO_terms-class`, `overLapper()`, `show_heatmap()`

Other `GO_clusters`: `GO_clusters-class`, `G0clusters_heatmap()`, `clusters_cor()`, `compare_clusters()`, `show_heatmap()`

Other visualization: `G0clusters_heatmap()`, `G0count()`, `G0terms_heatmap()`, `Upset()`, `available_organisms()`, `overLapper()`, `show_heatmap()`

Examples

```
# load example object
data(
  myGOs,
  package="ViSEAGO"
)

# display merge_enrich_terms output
ViSEAGO::show_table(myGOs)

# print merge_enrich_terms output
ViSEAGO::show_table(
  myGOs,
  "myGOs.txt"
)

## Not run:
# compute GO terms Semantic Similarity distances
myGOs<-ViSEAGO::compute_SS_distances(
  distance="Wang"
)

# GOtermsHeatmap with default parameters
Wang_clusters_wardD2<-ViSEAGO::GOterms_heatmap(
  myGOs,
  showIC=TRUE,
  showGOlabels=TRUE,
  GO.tree=list(
    tree=list(
      distance="Wang",
      aggreg.method="ward.D2",
      rotate=NULL
    ),
    cut=list(
      dynamic=list(
        pamStage=TRUE,
        pamRespectsDendro=TRUE,
        deepSplit=2,
        minClusterSize =2
      )
    )
  ),
  samples.tree=NULL
)

# display table of GO_clusters-class object
ViSEAGO::show_table(Wang_clusters_wardD2)

# print table of GO_clusters-class object
ViSEAGO::show_table(
  Wang_clusters_wardD2,
  "Wang_clusters_wardD2.txt"
```



```
)  
## End(Not run)
```

taxonomy	<i>Display Organism Scientific and common name from taxid.</i>
----------	----------------------------------------------------------------

Description

Display Organism Scientific and common name from taxid.

Usage

```
taxonomy(...)
```

Details

This internal function use [E-utilities](#) summary to display in [data.table](#) Organism Scientific name and common name, form a [vector](#) of taxid.

Value

a [data.table](#).

See Also

Other genomic_ressource: [Bioconductor2G0\(\)](#), [Custom2G0\(\)](#), [Ensembl2G0\(\)](#), [EntrezGene2G0\(\)](#), [Uniprot2G0\(\)](#), [annotate\(\)](#), [available_organisms\(\)](#), [genomic_ressource-class](#)

Examples

```
# Organism Scientific and common name from taxid  
Data<-ViSEAG0::taxonomy("9031")
```

Uniprot2G0	<i>Check available organisms databases at Uniprot.</i>
------------	--------------------------------------------------------

Description

Check the [Uniprot-GOA](#) available organisms.

Usage

```
Uniprot2G0()
```

Details

This function downloads the `current_release_numbers` file (ftp://ftp.ebi.ac.uk/pub/databases/GO/goa/current_release_numbers) from **Uniprot-GOA** which contains available organisms.

Value

a `genomic_ressource-class` object required by `annotate`.

References

Matt Dowle and Arun Srinivasan (2017). `data.table`: Extension of 'data.frame'. R package version 1.10.4. <https://CRAN.R-project.org/package=data.table>.

Huntley, RP, Sawford, T, Mutowo-Meullenet, P, Shypitsyna, A, Bonilla, C, Martin, MJ, O'Donovan, C (2015). The GOA database: gene Ontology annotation updates for 2015. *Nucleic Acids Res.*, 43, Database issue:D1057-63.

See Also

Other `genomic_ressource`: `Bioconductor2GO()`, `Custom2GO()`, `Ensembl2GO()`, `EntrezGene2GO()`, `annotate()`, `available_organisms()`, `genomic_ressource-class`, `taxonomy()`

Examples

```
## Not run:
# List Uniprot-GOA available organisms
Uniprot<-ViSEAGO::Uniprot2GO()

## End(Not run)
```

Upset

Enriched GO terms intersections plot.

Description

This method allows to visualize GO terms intersections between results of enrichment tests.

Usage

```
Upset(object, file = "./upset.xls")

## S4 method for signature 'ANY'
Upset(object, file = "./upset.xls")
```

Arguments

`object` an `enrich_GO_terms-class` or `GO_clusters-class` objects.
`file` output file name (default to `./upset.xls`)

Details

This function displays and print the intersections of enriched GO terms ($p < 0.01$) between all results provided by [enrich_GO_terms-class](#) or [GO_clusters-class](#) objects. The intersections are shown in an upset plot and printed in a table.

Value

print table and upset.

See Also

Other `enrich_GO_terms`: [enrich_GO_terms-class](#), [overLapper\(\)](#), [show_heatmap\(\)](#), [show_table\(\)](#)

Other visualization: [GOclusters_heatmap\(\)](#), [GOcount\(\)](#), [GOterms_heatmap\(\)](#), [available_organisms\(\)](#), [overLapper\(\)](#), [show_heatmap\(\)](#), [show_table\(\)](#)

Examples

```
# load example object
data(
  myGOs,
  package="ViSEAGO"
)

# print upset
ViSEAGO: :Upset(myGOs)
```

ViSEAGO

ViSEAGO package

Description

Easier data mining of biological functions organized into clusters using Gene Ontology and semantic.

Details

The main objective of ViSEAGO workflow is to carry out a data mining of biological functions and establish links between genes involved in the study. We developed ViSEAGO in R to facilitate functional Gene Ontology (GO) analysis of complex experimental design with multiple comparisons of interest.

It allows to study large-scale datasets together and visualize GO profiles to capture biological knowledge. The acronym stands for three major concepts of the analysis: Visualization, Semantic similarity and Enrichment Analysis of Gene Ontology ([pkgdiagram](#)).

It provides access to the last current GO annotations ([annotate](#)), which are retrieved from one of NCBI EntrezGene ([Bioconductor2GO](#), [EntrezGene2GO](#)), Ensembl ([Ensembl2GO](#)) or Uniprot ([Uniprot2GO](#)) databases for available species ([available_organisms](#)).

ViSEAGO extends classical functional GO analysis (`create_topGOdata`) to focus on functional coherence by aggregating closely related biological themes while studying multiple datasets at once (`merge_enrich_terms`).

It provides both a synthetic and detailed view using interactive functionalities respecting the GO graph structure (`MDSplot`, `GOterms_heatmap`, `GOclusters_heatmap`), and ensuring functional coherence supplied by semantic similarity (`build_GO_SS`, `compute_SS_distances`).

ViSEAGO has been successfully applied on several datasets from different species with a variety of biological questions. Results can be easily shared between bioinformaticians and biologists, enhancing reporting capabilities while maintaining reproducibility.

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