Package ‘enrichit’

March 10, 2026

Title 'C++' Implementations of Functional Enrichment Analysis

Version 0.1.3

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Description Fast implementations of functional enrichment analysis methods using 'C++' via 'Rcpp'.
Currently provides Over-
Representation Analysis (ORA) and Gene Set Enrichment Analysis (GSEA).
The multilevel GSEA algorithm is derived from the 'fgsea' package.
Methods are described in Subramanian et al. (2005) <doi:10.1073/pnas.0506580102> and Korotkevich et al. (2021) <doi:10.1101/060012>.

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Depends R (>= 3.5.0)

Imports methods, Rcpp (>= 1.0.10), stats, yulab.utils (> 0.2.1)

LinkingTo Rcpp

Suggests AnnotationDbi, clusterProfiler, DOSE, gson, qvalue, quarto, testthat

Encoding UTF-8

VignetteBuilder quarto

RoxygenNote 7.3.3

NeedsCompilation yes

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Repository CRAN

Date/Publication 2026-03-10 06:10:15 UTC

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`compareClusterResult-class` *Class "compareClusterResult" This class represents the comparison result of gene clusters by GO categories at specific level or GO enrichment analysis.*

Description

Class "compareClusterResult" This class represents the comparison result of gene clusters by GO categories at specific level or GO enrichment analysis.

Slots

`compareClusterResult` cluster comparing result

`geneClusters` a list of genes

`fun` one of groupGO, enrichGO and enrichKEGG

`gene2Symbol` gene ID to Symbol

`keytype` Gene ID type

`readable` logical flag of gene ID in symbol or not.

`.call` function call

`termsim` Similarity between term

`method` method of calculating the similarity between nodes

`dr` dimension reduction result

`organism` organism

Author(s)

Guangchuang Yu `https://yulab-smu.top`

See Also

`enrichResult`

`enrichit_params` *Common parameters for enrichit functions*

Description

Common parameters for enrichit functions

Arguments

`geneList`	A named numeric vector of gene statistics (e.g., log fold change), ranked in descending order.
`gene_sets`	A named list of gene sets. Each element is a character vector of genes.
`nPerm`	Number of permutations for p-value calculation (default: 1000).
`exponent`	Weighting exponent for enrichment score (default: 1.0).
`minGSSize`	minimal size of each geneSet for analyzing
`maxGSSize`	maximal size of each geneSet for analyzing
`pvalueCutoff`	P-value cutoff.
`pAdjustMethod`	P-value adjustment method (e.g., "BH").
`verbose`	Logical. Print progress messages.
`gson`	A GSON object containing gene set information.
`method`	Permutation method.
`adaptive`	Logical. Use adaptive permutation.
`minPerm`	Minimum permutations for adaptive mode.
`maxPerm`	Maximum permutations for adaptive mode.
`pvalThreshold`	P-value threshold for early stopping.

`enrichResult-class` *Class "enrichResult" This class represents the result of enrichment analysis.*

Description

Class "enrichResult" This class represents the result of enrichment analysis.

Slots

`result`	enrichment analysis
`pvalueCutoff`	pvalueCutoff
`pAdjustMethod`	pvalue adjust method
`qvalueCutoff`	qvalueCutoff
`organism`	only "human" supported
`ontology`	biological ontology
`gene`	Gene IDs
`keytype`	Gene ID type
`universe`	background gene
`gene2Symbol`	mapping gene to Symbol
`geneSets`	gene sets
`readable`	logical flag of gene ID in symbol or not.
`termsim`	Similarity between term
`method`	method of calculating the similarity between nodes
`dr`	dimension reduction result

Author(s)

Guangchuang Yu https://yulab-smu.top

`EXTID2NAME` *EXTID2NAME*

Description

mapping gene ID to gene Symbol

Usage

```
EXTID2NAME(OrgDb, geneID, keytype, toType = "SYMBOL")
```

Arguments

`OrgDb`	OrgDb
`geneID`	entrez gene ID
`keytype`	keytype
`toType`	ID type of the output

Value

gene symbol

Author(s)

Guangchuang Yu https://yulab-smu.top

`geneID` *geneID generic*

Description

geneID generic

Usage

```
geneID(x)
```

Arguments

`x`	enrichResult object

Value

’geneID’ return the ’geneID’ column of the enriched result which can be converted to data.frame via ’as.data.frame’

Examples

```
data(geneList, package="DOSE")
de <- names(geneList)[1:100]
x <- DOSE::enrichDO(de)
geneID(x)
```

`geneInCategory` *geneInCategory generic*

Description

geneInCategory generic

Usage

```
geneInCategory(x)
```

Arguments

`x`	enrichResult

Value

’geneInCategory’ return a list of genes, by spliting the input gene vector to enriched functional categories

Examples

```
data(geneList, package="DOSE")
de <- names(geneList)[1:100]
x <- DOSE::enrichDO(de)
geneInCategory(x)
```

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gsea *Gene Set Enrichment Analysis (GSEA)*

Description

Perform Gene Set Enrichment Analysis (GSEA) using a ranked gene list.

Usage

```
gsea(
  geneList,
  gene_sets,
  minGSSize = 10,
  maxGSSize = 500,
  nPerm = 1000,
  exponent = 1,
  method = "multilevel",
  adaptive = FALSE,
  minPerm = 101,
  maxPerm = 1e+05,
  pvalThreshold = 0.1,
  eps = 1e-10,
  sampleSize = 101,
  seed = FALSE,
  nPermSimple = 1000,
  scoreType = "std",
  verbose = TRUE
)
```

Arguments

`geneList`	A named numeric vector of gene statistics (e.g., log fold change), ranked in descending order.
`gene_sets`	A named list of gene sets. Each element is a character vector of genes.
`minGSSize`	minimal size of each geneSet for analyzing
`maxGSSize`	maximal size of each geneSet for analyzing
`nPerm`	Number of permutations for p-value calculation (default: 1000).
`exponent`	Weighting exponent for enrichment score (default: 1.0).

`method`	Permutation method.
`adaptive`	Logical. Use adaptive permutation.
`minPerm`	Minimum permutations for adaptive mode.
`maxPerm`	Maximum permutations for adaptive mode.
`pvalThreshold`	P-value threshold for early stopping.
`eps`	Epsilon for multilevel methods (default: 1e-10). Sets the smallest p-value that can be estimated.
`sampleSize`	Sample size for multilevel methods (default: 101).
`seed`	Random seed for reproducibility (default: FALSE). If FALSE, a random seed is generated.
`nPermSimple`	Number of permutations for the simple method (default: 1000).
`scoreType`	Type of enrichment score calculation: "std", "pos", "neg" (default: "std").
`verbose`	Logical. Print progress messages.

Value

A data.frame with columns:

- **ID**: Gene set name
- **enrichmentScore**: Enrichment Score
- **NES**: Normalized Enrichment Score
- **pvalue**: Empirical p-value from permutation test
- **setSize**: Size of the gene set (number of genes found in geneList)
- **nPerm**: (adaptive mode only) Actual number of permutations used
- **rank**: Rank at which the maximum enrichment score is attained
- **leading_edge**: Leading edge statistics (tags, list, signal)
- **core_enrichment**: Genes in the leading edge, separated by '/'

Examples

```
# Example data
stats <- rnorm(1000)
names(stats) <- paste0("Gene", 1:1000)
stats <- sort(stats, decreasing = TRUE)

gs1 <- paste0("Gene", 1:50)
gs2 <- paste0("Gene", 500:550)
gene_sets <- list(Pathway1 = gs1, Pathway2 = gs2)

# Use default fixed permutation method
result <- gsea(geneList=stats, gene_sets=gene_sets, nPerm=100)

# Use adaptive permutation for more accurate p-values

result_adaptive <- gsea(geneList=stats, gene_sets=gene_sets, adaptive=TRUE)
```

`gseaResult-class` *Class "gseaResult" This class represents the result of GSEA analysis*

Description

Class "gseaResult" This class represents the result of GSEA analysis

Slots

`result` GSEA anaysis

`organism` organism

`setType` setType

`geneSets` geneSets

`geneList` order rank geneList

`keytype` ID type of gene

`permScores` permutation scores

`params` parameters

`gene2Symbol` gene ID to Symbol

`readable` whether convert gene ID to symbol

`dr` dimension reduction result

Author(s)

Guangchuang Yu https://yulab-smu.top

`gseaScores` *Calculate GSEA Running Enrichment Scores*

Description

Calculate GSEA Running Enrichment Scores

Usage

```
gseaScores(geneList, geneSet, exponent = 1, fortify = FALSE)
```

Arguments

`geneList`	a named numeric vector of gene statistics (e.g., t-statistics or log-fold changes), sorted in decreasing order.
`geneSet`	a character vector of gene IDs belonging to the gene set.
`exponent`	a numeric value defining the weight of the running enrichment score. Default is 1.
`fortify`	logical. If TRUE, returns a data frame with columns `x`, `runningScore`, and `position`. If FALSE (default), returns the enrichment score (ES).

Value

If `fortify = TRUE`, a data frame containing the running enrichment scores and positions. If `fortify = FALSE`, a numeric value representing the Enrichment Score (ES).

Author(s)

Guangchuang Yu

`gsea_gson` *gsea_gson*

Description

generic function for gene set enrichment analysis

Usage

```
gsea_gson(
  geneList,
  gson,
  nPerm = 1000,
  exponent = 1,
  minGSSize = 10,
  maxGSSize = 500,
  pvalueCutoff = 0.05,
  pAdjustMethod = "BH",
  method = "multilevel",
  adaptive = FALSE,
  minPerm = 101,
  maxPerm = 1e+05,
  pvalThreshold = 0.1,
  verbose = TRUE,
  ...
)
```

Arguments

`geneList`	A named numeric vector of gene statistics (e.g., log fold change), ranked in descending order.
`gson`	A GSON object containing gene set information.
`nPerm`	Number of permutations for p-value calculation (default: 1000).
`exponent`	Weighting exponent for enrichment score (default: 1.0).
`minGSSize`	minimal size of each geneSet for analyzing
`maxGSSize`	maximal size of each geneSet for analyzing
`pvalueCutoff`	P-value cutoff.

`pAdjustMethod`	P-value adjustment method (e.g., "BH").
`method`	Permutation method.
`adaptive`	Logical. Use adaptive permutation.
`minPerm`	Minimum permutations for adaptive mode.
`maxPerm`	Maximum permutations for adaptive mode.
`pvalThreshold`	P-value threshold for early stopping.
`verbose`	Logical. Print progress messages.
`...`	Additional parameters passed to gsea()

Value

gseaResult object

Author(s)

Guangchuang Yu

`gsfilter` *gsfilter*

Description

filter enriched result by gene set size or gene count

Usage

```
gsfilter(x, by = "GSSize", min = NA, max = NA)
```

Arguments

`x`	instance of enrichResult or compareClusterResult
`by`	one of 'GSSize' or 'Count'
`min`	minimal size
`max`	maximal size

Value

update object

Author(s)

Guangchuang Yu

`ora` *Over-Representation Analysis (ORA)*

Description

Perform over-representation analysis using hypergeometric test (Fisher's exact test).

Usage

```
ora(gene, gene_sets, universe)
```

Arguments

`gene`	Character vector of differentially expressed genes (or gene list of interest).
`gene_sets`	A named list of gene sets. Each element is a character vector of genes.
`universe`	Character vector of background genes (e.g., all genes in the platform).

Value

A data.frame with columns:

`GeneSet`	Gene set name
`SetSize`	Number of genes in the gene set (intersected with universe)
`DEInSet`	Number of differentially expressed genes in the gene set
`DESize`	Total number of differentially expressed genes in universe
`PValue`	Raw p-value from hypergeometric test

Examples

```
# Example data
de_genes <- c("Gene1", "Gene2", "Gene3", "Gene4", "Gene5")
all_genes <- paste0("Gene", 1:1000)

gs1 <- paste0("Gene", 1:50)
gs2 <- paste0("Gene", 51:150)
gs3 <- paste0("Gene", 151:300)
gene_sets <- list(Pathway1 = gs1, Pathway2 = gs2, Pathway3 = gs3)

result <- ora(gene=de_genes, gene_sets=gene_sets, universe=all_genes)
head(result)
```

`ora_gson` *ora-gson*

Description

interal method for enrichment analysis

Usage

```
ora_gson(
  gene,
  pvalueCutoff,
  pAdjustMethod = "BH",
  universe = NULL,
  minGSSize = 10,
  maxGSSize = 500,
  qvalueCutoff = 0.2,
  gson
)
```

Arguments

`gene`	a vector of entrez gene id.
`pvalueCutoff`	P-value cutoff.
`pAdjustMethod`	P-value adjustment method (e.g., "BH").
`universe`	background genes, default is the intersection of the 'universe' with genes that have annotations. Users can set `options(enrichment_force_universe = TRUE)` to force the 'universe' untouched.
`minGSSize`	minimal size of each geneSet for analyzing
`maxGSSize`	maximal size of each geneSet for analyzing
`qvalueCutoff`	cutoff of qvalue
`gson`	A GSON object containing gene set information.

Details

using the hypergeometric model

Value

A `enrichResult` instance.

Author(s)

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`setReadable` *setReadable*

Description

mapping geneID to gene Symbol

Usage

```
setReadable(x, OrgDb, keyType = "auto", toType = "SYMBOL")
```

Arguments

`x`	enrichResult Object
`OrgDb`	OrgDb
`keyType`	keyType of gene
`toType`	ID type of the output

Value

enrichResult Object

Author(s)

Guangchuang Yu

`show` *show method*

Description

show method for `gseaResult` instance

show method for `enrichResult` instance

Usage

```
show(object)

show(object)
```

Arguments

`object`	A `enrichResult` instance.

Value

message

message

Author(s)

Guangchuang Yu `https://yulab-smu.top`

`summary` *summary method*

Description

summary method for `gseaResult` instance

summary method for `enrichResult` instance

Usage

```
summary(object, ...)

summary(object, ...)
```

Arguments

`object`	A `enrichResult` instance.
`...`	additional parameter

Value

A data frame

A data frame

Author(s)

Guangchuang Yu `https://yulab-smu.top`

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