

Package ‘SeqGSEA’

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Type Package

Title Gene Set Enrichment Analysis (GSEA) of RNA-Seq Data: integrating differential expression and splicing

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Author Xi Wang <Xi.Wang@newcastle.edu.au>

Maintainer Xi Wang <Xi.Wang@newcastle.edu.au>

Description The package generally provides methods for gene set enrichment analysis of high-throughput RNA-Seq data by integrating differential expression and splicing. It uses negative binomial distribution to model read count data, which accounts for sequencing biases and biological variation. Based on permutation tests, statistical significance can also be achieved regarding each gene’s differential expression and splicing, respectively.

License GPL (>= 3)

Depends Biobase, DESeq, biomaRt, foreach

Imports methods, doParallel

biocViews HighThroughputSequencing, RNAseq, GeneSetEnrichment, GeneExpression, Differential-Expression

R topics documented:

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SeqGSEA-package	<i>SeqGSEA: a Bioconductor package for gene set enrichment analysis of RNA-Seq data</i>
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Description

SeqGSEA is an R package for gene set enrichment analysis of RNA-Seq data with the ability to integrate differential expression and differential splice in functional analysis.

Details

Package: SeqGSEA
 Type: Package
 License: GPL (>= 3)

A User's Guide is available as well as the usual help page documentation for each of the individual functions.

The most useful functions are listed below:

* ReadCountSet class

- [ReadCountSet-class](#)
- [ReadCountSet](#)
- [exonID](#)
- [geneID](#)
- [counts-methods](#)
- [label](#)
- [subsetByGenes](#)

* SeqGeneSet class

- [SeqGeneSet-class](#)
- [geneSetDescs](#)
- [geneSetNames](#)
- [geneSetSize](#)
- [size](#)

* Load data

- [newReadCountSet](#)
- [loadExonCountData](#)

- newGeneSets
- loadGenesets
- * DE analysis
 - getGeneCount
 - runDESeq
 - DENBStat4GSEA
 - DENBStatPermut4GSEA
 - DENBTest
 - DEpermutePval
- * DS analysis
 - DSpermute4GSEA
 - DSpermutePval
 - exonTestability
 - geneTestability
 - estiExonNBstat
 - estiGeneNBstat
- * GSEA main
 - GSEnrichAnalyze
 - caLES
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 - genePermuteScore
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 - rankCombine
 - normES
 - normFactor
 - scoreNormalization
 - signifES
- * Result tables
 - GSEAResultTable
 - DSresultExonTable
 - DSresultGeneTable
 - topDEGenes
 - topDSExons
 - topDSGenes
 - topGeneSets

* Result displays

- [plotES](#)
- [plotGeneScore](#)
- [plotSig](#)
- [plotSigGeneSet](#)
- [writeSigGeneSet](#)

* Miscellaneous

- [genpermuteMat](#)
- [convertEnsembl2Symbol](#)
- [convertSymbol2Ensembl](#)

Author(s)

Xi Wang and Murray J. Cairns

Maintainer: Xi Wang <xi.wang@newcastle.edu.au>

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. *BMC Bioinformatics*, 14(Suppl 5):S16.

calES

Calculate running enrichment scores of gene sets

Description

This is an internal function to calculate running enrichment scores of each gene set in the SeqGeneSet object specified

Usage

```
calES(gene.set, gene.score, weighted.type = 1)
```

Arguments

`gene.set` a SeqGeneSet object.
`gene.score` a vector of gene scores corresponding to the `geneList` slot of `gene.set`.
`weighted.type` gene score weight type.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[GSEnrichAnalyze](#), [calES.perm](#),

Examples

```
data(DEscore, package="SeqGSEA")
data(DSscore, package="SeqGSEA")
gene.score <- geneScore(DEscore, DSscore, method="linear", DEweight = 0.3)
data(GS_example, package="SeqGSEA")
rES <- calES(GS_example, gene.score)
rES[1,]
```

calES.perm

Calculate enrichment scores for gene sets in the permutation data sets

Description

This is an internal function to calculate enrichment scores for gene sets in the permutation data sets.

Usage

```
calES.perm(gene.set, gene.score.perm, weighted.type = 1)
```

Arguments

gene.set a SeqGeneSet object.
gene.score.perm a matrix of gene scores on the permutation data sets.
weighted.type gene score weight type.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[GSEnrichAnalyze](#), [calES](#),

Examples

```
data(DEscore.perm, package="SeqGSEA")
data(DSscore.perm, package="SeqGSEA")
gene.score.perm <- genePermuteScore(DEscore.perm, DSscore.perm, method="linear", DEweight=0.3)
data(GS_example, package="SeqGSEA")
ES.perm <- calES.perm(GS_example, gene.score.perm)
ES.perm[1:5,1:5]
```

`convertEnsembl2Symbol` *Convert ensembl gene IDs to gene symbols*

Description

Convert ensembl gene IDs to gene symbols

Usage

```
convertEnsembl2Symbol(ensembl.genes)
```

Arguments

`ensembl.genes` ensembl gene ID(s).

Value

A 2-column matrix showing the correspondence of ensembl gene IDs and gene symbols.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[convertSymbol2Ensembl](#)

Examples

```
convertEnsembl2Symbol("ENSG00000162946") #DISC1
```

`convertSymbol2Ensembl` *Convert gene symbols to ensembl gene IDs*

Description

Convert gene symbols to ensembl gene IDs

Usage

```
convertSymbol2Ensembl(symbols)
```

Arguments

`symbols` gene symbol(s).

Value

A 2-column matrix showing the correspondence of gene symbols and ensembl gene IDs.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[convertEnsembl2Symbol](#)

Examples

```
convertSymbol2Ensembl("DISC1") #ENSG00000162946
```

counts-methods

Accessors for the 'counts' slot of a ReadCountSet object.

Description

Accessors for the 'counts' slot of a ReadCountSet object.

Usage

```
## S4 method for signature 'ReadCountSet'  
counts(object)  
## S4 replacement method for signature 'ReadCountSet,matrix'  
counts(object) <- value
```

Arguments

object	a ReadCountSet object
value	a matrix of read counts

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

Examples

```
data(RCS_example, package="SeqGSEA")  
readCounts <- counts(RCS_example)  
head(readCounts)
```

DENBStat4GSEA	<i>Calculate NB-statistics quantifying differential expression for each gene</i>
---------------	--

Description

Calculate NB-statistics quantifying differential expression between two groups of samples compared. The results will be used for GSEA run. Comparing with [DENBTest](#), this function will not calculate NB test p-values.

This function only works with two-group comparison.

Usage

```
DENBStat4GSEA(cds)
```

Arguments

cds	A CountDataSet object with size factors and dispersion parameters estimated. Recommended to take the output of runDESeq .
-----	---

Value

A data frame containing each gene's expression means and variances in each group, and each gene's DE NB-statistics.

Note

The results with the output of [DENBStatPermut4GSEA](#) can also be used to run [DEpermutePval](#).

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. *BMC Bioinformatics*, 14(Suppl 5):S16.

See Also

[DENBTest](#), [runDESeq](#), [DENBStatPermut4GSEA](#)

Examples

```
data(RCS_example, package="SeqGSEA")
geneCounts <- getGeneCount(RCS_example)
label <- label(RCS_example)
DEG <- runDESeq(geneCounts, label)
DEGres <- DENBStat4GSEA(DEG)
head(DEGres)
```

DENBStatPermut4GSEA	<i>Calculate NB-statistics quantifying DE for each gene in the permutation data sets</i>
---------------------	--

Description

Calculate NB-statistics quantifying differential expression for each gene in the permutation data sets. The results will be used for GSEA run.

Usage

```
DENBStatPermut4GSEA(DEG, permuteMat)
```

Arguments

DEG	a CountDataSet object, can be the output of runDESeq .
permuteMat	a permutation matrix generated by genpermuteMat .

Value

A matrix of NB-statistics. Each row corresponds to each gene, and each column to each permutation.

Note

The results with the output of [DENBStat4GSEA](#) can also be used to run [DEpermutePval](#).

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. *BMC Bioinformatics*, 14(Suppl 5):S16.

See Also

[DENBStat4GSEA](#), [runDESeq](#), [DEpermutePval](#), [genpermuteMat](#)

Examples

```
data(RCS_example, package="SeqGSEA")
permuteMat <- genpermuteMat(RCS_example, times=10)
geneCounts <- getGeneCount(RCS_example)
label <- label(RCS_example)
DEG <- runDESeq(geneCounts, label)
DEpermNBstat <- DENBStatPermut4GSEA(DEG, permuteMat)
DEpermNBstat[1:10,1:10]
```

DENBTest*Perform negative binomial exact test for differential expression*

Description

Perform negative binomial exact test for differential expression - a modified version of `nbinomTest` in `DESeq` package.

Usage

```
DENBTest(cds)
```

Arguments

`cds` A `CountDataSet` object with size factors and dispersion parameters estimated. Recommended to take the output of `runDESeq`.

Value

A data frame of the test results. Information contains mean expression values, NB-statistics, (log) fold-changes, p-values, and adjusted p-values.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Anders, S. and Huber, W. (2010) Differential expression analysis for sequence count data, *Genome Biol*, 11, R106.

See Also

[runDESeq](#), [DENBStat4GSEA](#)

Examples

```
data(RCS_example, package="SeqGSEA")
geneCounts <- getGeneCount(RCS_example)
label <- label(RCS_example)
DEG <- runDESeq(geneCounts, label)
DEGres <- DENBTest(DEG)
head(DEGres)
```

DEpermutePval

Permutation for p-values in differential expression analysis

Description

Calculate permutation p-values in differential expression analysis for each genes.

Usage

```
DEpermutePval(DEGres, permuteNBstat)
```

Arguments

DEGres the output of [DENBStat4GSEA](#).
permuteNBstat the output of [DENBStatPermut4GSEA](#).

Value

A data frame containing the expression means and variances for each gene in each group compared, and NB-stats, permutation p-values and adjusted p-values for each gene.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[runDESeq](#), [DENBStat4GSEA](#), [DENBStatPermut4GSEA](#), [DENBTest](#)

Examples

```
data(RCS_example, package="SeqGSEA")
permuteMat <- genpermuteMat(RCS_example, times=10)
geneCounts <- getGeneCount(RCS_example)
label <- label(RCS_example)
DEG <- runDESeq(geneCounts, label)
DEGres <- DENBStat4GSEA(DEG)
DEpermNBstat <- DENBStatPermut4GSEA(DEG, permuteMat)
DEGres <- DEpermutePval(DEGres, DEpermNBstat)
head(DEGres)
```

DEscore	<i>Pre-calculated DE/DS scores</i>
---------	------------------------------------

Description

DEscore and DSscore are pre-calculated DE and DS scores, respectively; DEscore.perm and DSscore.perm are pre-calculated DE and DS scores on the permutation data sets, respectively; They are used in examples of the SeqGSEA package. Note that these scores are of no meaning but to demonstrate the usage of functions.

Usage

```
data("DEscore")
data("DEscore.perm")
data("DSscore")
data("DSscore.perm")
```

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. *BMC Bioinformatics*, 14(Suppl 5):S16.

DSpermute4GSEA	<i>Compute NB-statistics quantifying differential splicing on the permutation data set.</i>
----------------	---

Description

This function is to calculate NB-statistics quantifying differential splicing for each gene on each permutation data set. The results will be used for GSEA run as DS background.

Usage

```
DSpermute4GSEA(RCS, permuteMat)
```

Arguments

RCS	a ReadCountSet object after running exonTestability .
permuteMat	a permutation matrix generated by genpermuteMat .

Details

Parallel running configuration: TODO

Value

A ReadCountSet object with slot `permute_NBstat_gene` updated.

Note

Please run [exonTestability](#) before run this function.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. *BMC Bioinformatics*, 14(Suppl 5):S16.

See Also

[exonTestability](#), [genpermuteMat](#), [DENBStatPermut4GSEA](#), [DSpermutePval](#)

Examples

```
data(RCS_example, package="SeqGSEA")
permuteMat <- genpermuteMat(RCS_example, times=10)
RCS_example <- exonTestability(RCS_example)
RCS_example <- DSpermute4GSEA(RCS_example, permuteMat)
head(RCS_example@permute_NBstat_gene)
```

DSpermutePval

Permutation for p-values in differential splicing analysis

Description

Calculate permutation p-values in differential splicing analysis.

Usage

```
DSpermutePval(RCS, permuteMat)
```

Arguments

RCS a ReadCountSet object after running [estiExonNBstat](#) and [estiGeneNBstat](#).
permuteMat a permutation matrix generated by [genpermuteMat](#).

Details

Permutation p-values are computed based on NB-statistics for comparison of the studied groups and NB-statistics from the permutation data sets.

Value

A ReadCountSet object with slots permute_NBstat_exon, permute_NBstat_gene, featureData, and featureData_gene updated.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. BMC Bioinformatics, 14(Suppl 5):S16.

See Also

[estiExonNBstat](#), [estiGeneNBstat](#), [genpermuteMat](#), [DSpermute4GSEA](#)

Examples

```
data(RCS_example, package="SeqGSEA")
permuteMat <- genpermuteMat(RCS_example, times=10)
RCS_example <- exonTestability(RCS_example)
RCS_example <- estiExonNBstat(RCS_example)
RCS_example <- estiGeneNBstat(RCS_example)
RCS_example <- DSpermutePval(RCS_example, permuteMat)
head(DSresultExonTable(RCS_example))
head(DSresultGeneTable(RCS_example))
```

DSresultExonTable *Form a table for DS analysis results at the Exon level*

Description

Form a table for differential splicing analysis results at the Exon level.

Usage

```
DSresultExonTable(RCS)
```

Arguments

RCS A ReadCountSet object with [DSpermutePval](#) done.

Details

A data frame containing each exon's NB-statistics, p-values and adjusted p-values for differential splicing analysis.

Value

A matrix containing exon DS analysis results, including testability, NBstats, p-values and adjusted p-values.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[DSresultGeneTable](#), [DSpermutePval](#)

Examples

```
data(RCS_example, package="SeqGSEA")
permuteMat <- genpermuteMat(RCS_example, times=10)
RCS_example <- exonTestability(RCS_example)
RCS_example <- estiExonNBstat(RCS_example)
RCS_example <- estiGeneNBstat(RCS_example)
RCS_example <- DSpermutePval(RCS_example, permuteMat)
head(DSresultExonTable(RCS_example))
```

DSresultGeneTable	<i>Form a table for DS analysis results at the gene level</i>
-------------------	---

Description

Form a table for differential splicing analysis results at the gene level.

Usage

```
DSresultGeneTable(RCS)
```

Arguments

RCS A ReadCountSet object with [DSpermutePval](#) done.

Value

A data frame containing each gene's NB-statistics, p-values and adjusted p-values for differential splicing analysis.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[DSresultExonTable](#), [DSpermutePval](#)

Examples

```
data(RCS_example, package="SeqGSEA")
permuteMat <- genpermuteMat(RCS_example, times=10)
RCS_example <- exonTestability(RCS_example)
RCS_example <- estiExonNBstat(RCS_example)
RCS_example <- estiGeneNBstat(RCS_example)
RCS_example <- DSpermutePval(RCS_example, permuteMat)
head(DSresultGeneTable(RCS_example))
```

estiExonNBstat	<i>Calculate NB-statistics quantifying differential splicing for individual exons</i>
----------------	---

Description

Calculate NB-statistics quantifying differential splicing for individual exons between two groups of samples compared.

Usage

```
estiExonNBstat(RCS)
```

Arguments

RCS a ReadCountSet object after running `exonTestability`.

Value

A ReadCountSet object with the slot `featureData` updated.

Note

Please run [exonTestability](#) before you run this function.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Weichen Wang, Zhiyi Qin, Zhixing Feng, Xi Wang and Xuegong Zhang (2013). Identifying differentially spliced genes from two groups of RNA-seq samples. *Gene*, 518(1):164-170.

See Also

[exonTestability](#), [estiGeneNBstat](#)

Examples

```
data(RCS_example, package="SeqGSEA")
RCS_example <- exonTestability(RCS_example, cutoff=5)
RCS_example <- estiExonNBstat(RCS_example)
head(fData(RCS_example))
```

estiGeneNBstat	<i>Calculate NB-statistics quantifying differential splicing for each gene</i>
----------------	--

Description

Calculate NB-statistics quantifying differential splicing for each gene between two groups of samples compared. The results will be used for GSEA run (as DS-scores).

Usage

```
estiGeneNBstat(RCS)
```

Arguments

RCS a ReadCountSet object after running estiExonNBstat.

Value

A ReadCountSet object with slot featureData_gene updated.

Note

Please run [estiExonNBstat](#) before run this function.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Weichen Wang, Zhiyi Qin, Zhixing Feng, Xi Wang and Xuegong Zhang (2013). Identifying differentially spliced genes from two groups of RNA-seq samples. *Gene*, 518(1):164-170.

See Also

[estiExonNBstat](#)

Examples

```
data(RCS_example, package="SeqGSEA")
RCS_example <- exonTestability(RCS_example, cutoff=5)
RCS_example <- estiExonNBstat(RCS_example)
RCS_example <- estiGeneNBstat(RCS_example)
head(RCS_example@featureData_gene)
```

exonID	<i>Accessor to the exonID slot of ReadCountSet objects</i>
--------	--

Description

Accessor to the exonID slot of ReadCountSet objects

Usage

```
exonID(RCS)
exonID(RCS) <- value
```

Arguments

RCS	a ReadCountSet object
value	a vector of exon IDs

Value

A character vector of exon IDs; or a ReadCountSet object.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[newReadCountSet](#), [geneID](#)

Examples

```
data(RCS_example, package="SeqGSEA")
exonID(RCS_example)
```

exonTestability	<i>Check exon testability</i>
-----------------	-------------------------------

Description

Check exon testability, filtering out exons with very few (default: 5) read counts

Usage

```
exonTestability(RCS, cutoff = 5)
```

Arguments

RCS a ReadCountSet object.
cutoff exons with read counts less than this cutoff are to be marked as untestable.

Value

a ReadCountSet object with slot fData updated.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[geneTestability](#)

Examples

```
data(RCS_example, package="SeqGSEA")  
RCS_example <- exonTestability(RCS_example, cutoff=5)  
head(fData(RCS_example))
```

geneID

Accessor to the geneID slot of ReadCountSet objects

Description

Accessor to the geneID slot of ReadCountSet objects

Usage

```
geneID(RCS)  
geneID(RCS) <- value
```

Arguments

RCS a ReadCountSet object
value a vector of gene IDs

Value

A character vector of gene IDs, which can be duplicated; or a ReadCountSet object.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[newReadCountSet](#), [exonID](#)

Examples

```
data(RCS_example, package="SeqGSEA")
geneID(RCS_example)
```

geneList

Get the gene list in a SeqGeneSet object

Description

Get the gene list in a SeqGeneSet object

Usage

```
geneList(GS)
```

Arguments

GS A SeqGeneSet object.

Details

TBA

Value

A vector of gene IDs.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[loadGenesets](#), [SeqGeneSet-class](#)

Examples

```
##
gs <- newGeneSets(GS=list(1:10, 6:15, 11:20),
                  geneList=paste("Gene", 1:22, sep=""),
                  GSNames=c("gs1", "gs2", "gs3"),
                  GSDescs=c("test1", "test2", "test3"),
                  name="gs examples")

geneList(gs)
## End
```

genePermuteScore *Calculate gene scores on permutation data sets*

Description

Calculate gene scores on permutation data sets

Usage

```
genePermuteScore(DEscoreMat, DSscoreMat, method = c("linear", "quadratic", "rank"),
                 DEweight = 0.5)
```

Arguments

DEscoreMat	normalized DE scores on permutation data sets.
DSscoreMat	normalized DS scores on permutation data sets.
method	one of the integration methods: linear, quadratic, or rank; default: linear.
DEweight	any number between 0 and 1 (included), the weight of differential expression scores (the weight for differential splice is (1-DEweight)).

Details

The integration methods are detailed in Wang and Cairns (2013). Here the rank method refers only to the method using data-set-specific ranks.

Value

A gene score matrix.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. BMC Bioinformatics, 14(Suppl 5):S16.

See Also

[geneScore](#)

Examples

```
data(DEscore.perm, package="SeqGSEA")
data(DSscore.perm, package="SeqGSEA")
gene.score.perm <- genePermuteScore(DEscore.perm, DSscore.perm, method="linear", DEweight=0.3)
```

geneScore	<i>Calculate gene scores by integrating DE and DS scores</i>
-----------	--

Description

Calculate gene scores by integrating DE and DS scores

Usage

```
geneScore(DEscore, DSscore, method = c("linear", "quadratic", "rank"), DEweight = 0.5)
```

Arguments

DEscore	normalized DE scores.
DSscore	normalized DS scores.
method	one of the integration methods: linear, quadratic, or rank; default: linear.
DEweight	any number between 0 and 1 (included), the weight of differential expression scores (the weight for differential splice is (1-DEweight)).

Details

The integration methods are detailed in Wang and Cairns (2013). Here the rank method refers only to the method using data-set-specific ranks.

Value

A vector of gene scores.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. BMC Bioinformatics, 14(Suppl 5):S16.

See Also

[genePermuteScore](#)

Examples

```
data(DEscore, package="SeqGSEA")
data(DSscore, package="SeqGSEA")
gene.score <- geneScore(DEscore, DSscore, method="linear", DEweight = 0.3)
```

geneSetDescs	<i>Get the descriptions of gene sets in a SeqGeneSet object</i>
--------------	---

Description

Get the descriptions of gene sets in a SeqGeneSet object

Usage

```
geneSetDescs(GS)
```

Arguments

GS a SeqGeneSet object.

Details

Gene sets with size less than GSSizeMin or more than GSSizeMax are not included.

Value

A vector of descriptions of each gene set in the SeqGeneSet object.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[geneSetNames](#), [geneSetSize](#), [SeqGeneSet-class](#), [loadGenesets](#)

Examples

```
data(GS_example, package="SeqGSEA")
geneSetDescs(GS_example)
```

geneSetNames	<i>Get the names of gene set in a SeqGeneSet object</i>
--------------	---

Description

Get the names of gene set in a SeqGeneSet object

Usage

```
geneSetNames(GS)
```

Arguments

GS a SeqGeneSet object.

Details

Gene sets with size less than GSSizeMin or more than GSSizeMax are not included.

Value

A vector of gene set names in this SeqGeneSet object.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[geneSetDescs](#), [geneSetSize](#), [SeqGeneSet-class](#), [loadGenesets](#)

Examples

```
data(GS_example, package="SeqGSEA")
geneSetNames(GS_example)
```

geneSetSize	<i>Get the numbers of genes in each gene set in a SeqGeneSet object</i>
-------------	---

Description

Get the numbers of genes in each gene set in a SeqGeneSet object

Usage

```
geneSetSize(GS)
```

Arguments

GS a SeqGeneSet object.

Details

Gene sets with size less than GSSizeMin or more than GSSizeMax are not included.

Value

A vector of integers indicating the number of genes in each gene set in this SeqGeneSet object.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[geneSetNames](#), [geneSetDescs](#), [SeqGeneSet-class](#), [loadGenesets](#)

Examples

```
data(GS_example, package="SeqGSEA")
geneSetSize(GS_example)
```

geneTestability	<i>Check gene testability</i>
-----------------	-------------------------------

Description

This function is to determine each gene's testability. A gene is testable if at least one of its exons are testable.

Usage

```
geneTestability(RCS)
```

Arguments

RCS a ReadCountSet object after exon testability checked, usually the output of [exonTestability](#).

Details

This result can applied to filter out genes not expressed.

Value

A logical vector indicating which genes are testable, i.e., having at least one exon testable.

Note

Please run [exonTestability](#) before run this function.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[exonTestability](#), [subsetByGenes](#)

Examples

```
data(RCS_example, package="SeqGSEA")
RCS_example <- exonTestability(RCS_example, cutoff=5)
geneTestable <- geneTestability(RCS_example)
head(geneTestable)
```

genpermuteMat	<i>Generate permutation matrix</i>
---------------	------------------------------------

Description

Generate permutation matrix.

Usage

```
genpermuteMat(RCS, times = 1000)
```

Arguments

RCS	a ReadCountSet object. This function needs the original sample label information from the ReadCountSet object.
times	an integer indication the times of permutation.

Value

A sample label shuffled matrix, rows corresponding to samples and columns for each permutation.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[DSpermute4GSEA](#), [DENBStatPermut4GSEA](#)

Examples

```
data(RCS_example, package="SeqGSEA")
permuteMat <- genpermuteMat(RCS_example, times=10)
RCS_example <- exonTestability(RCS_example)
RCS_example <- DSpermute4GSEA(RCS_example, permuteMat)
```

getGeneCount	<i>Calculate read counts of genes from a ReadCountSet object</i>
--------------	--

Description

Calculate read counts of genes from a ReadCountSet object

Usage

```
getGeneCount(RCS)
```

Arguments

RCS a ReadCountSet object

Details

This function can be used to get gene read counts from exon read counts.

Value

a matrix of gene read counts for each gene (row) and each sample (col).

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[loadExonCountData](#), [runDESeq](#)

Examples

```
data(RCS_example, package="SeqGSEA")
geneCounts <- getGeneCount(RCS_example)
```

GSEAResultTable	<i>Form a table for GSEA results</i>
-----------------	--------------------------------------

Description

Form a table for GSEA results.

Usage

```
GSEAResultTable(gene.set, GSDesc = FALSE)
```

Arguments

gene.set a SeqGeneSet object after running [GSEnrichAnalyze](#).
GSDesc logical indicating whether to output gene set descriptions. default: FALSE

Value

A data frame containing columns of GSName, GSSize, ES, ES.pos, pval, FDR, and FWER.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[GSEnrichAnalyze](#), [topGeneSets](#)

Examples

```
data(DEscore, package="SeqGSEA")
data(DSscore, package="SeqGSEA")
gene.score <- geneScore(DEscore, DSscore, method="linear", DEweight = 0.3)
data(DEscore.perm, package="SeqGSEA")
data(DSscore.perm, package="SeqGSEA")
gene.score.perm <- genePermuteScore(DEscore.perm, DSscore.perm, method="linear", DEweight=0.3)
data(GS_example, package="SeqGSEA")
GS_example <- GSEnrichAnalyze(GS_example, gene.score, gene.score.perm)
head(GSEAResultTable(GS_example))
```

GSEnrichAnalyze

Main function of gene set enrichment analysis

Description

The main function of gene set enrichment analysis

Usage

```
GSEnrichAnalyze(gene.set, gene.score, gene.score.perm, weighted.type = 1)
```

Arguments

<code>gene.set</code>	a SeqGeneSet object.
<code>gene.score</code>	a vector of integrated gene scores in the same order as genes listed in the <code>geneList</code> slot of <code>gene.set</code> .
<code>gene.score.perm</code>	a matrix of integrated gene scores on permutation data sets; row: genes; col: permutation.
<code>weighted.type</code>	weight type for gene scores; default: 1.

Value

A SeqGeneSet object with many slots updated, such as `GSEA.ES` and `GSEA.pval`.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. *BMC Bioinformatics*, 14(Suppl 5):S16.

See Also

[normES](#), [signifES](#)

Examples

```
data(DEscore, package="SeqGSEA")
data(DSscore, package="SeqGSEA")
gene.score <- geneScore(DEscore, DSscore, method="linear", DEweight = 0.3)
data(DEscore.perm, package="SeqGSEA")
data(DSscore.perm, package="SeqGSEA")
gene.score.perm <- genePermuteScore(DEscore.perm, DSscore.perm, method="linear", DEweight=0.3)
data(GS_example, package="SeqGSEA")
GS_example <- GSEnrichAnalyze(GS_example, gene.score, gene.score.perm)
topGeneSets(GS_example, 5)
```

GS_example

SeqGeneSet object example

Description

An exemplified SeqGeneSet object to demonstrate functions in the SeqGSEA package. This object was generated with collection #6 (C6) gene sets of the Molecular Signatures Database (MSigDB) v3.1.

Usage

```
data("GS_example")
```

References

Subramanian, A., Tamayo, P., Mootha, V. K., Mukherjee, S., Ebert, B. L., Gillette, M. A., Paulovich, A., Pomeroy, S. L., Golub, T. R., Lander, E. S., and Mesirov, J. P. (2005). Gene set enrichment analysis: a knowledge-based approach for interpreting genome-wide expression profiles. *Proc Natl Acad Sci USA*, 102(43): 15545-50.

label

Get the labels of samples in a ReadCountSet object

Description

Get the labels of samples in a ReadCountSet object

Usage

```
label(RCS)
```

Arguments

RCS a ReadCountSet object

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[newReadCountSet](#)

Examples

```
data(RCS_example, package="SeqGSEA")
label(RCS_example)
```

loadExonCountData *Load Exon Count Data*

Description

This function is used to load (sub-)exon count data. Exon count data can be got by the Python script `count_in_exons.py`.

Usage

```
loadExonCountData(case.files, control.files)
```

Arguments

`case.files` a character vector containing the exon count file names for case samples
`control.files` a character vector containing the exon count file names for control samples

Details

You may need the Python script `count_in_exons.py` (released with this package) to generate your exon count files from read mapping results (say BAM files). The detailed usage can be obtained by simply typing `python \path\to\count_in_exons.py`. Users can also use other scripts or software for exon read counting.

The format of the exon count file is:

```
GeneName1:001[tab]Count11
GeneName1:002[tab]Count12
...
GeneName1:00N[tab]Count1N
GeneName2:001[tab]Count21
...
```


Value

This function returns a ReadCountSet object.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[newReadCountSet](#), [ReadCountSet-class](#)

Examples

```
library(SeqGSEA)
dat.dir = system.file("extdata", package="SeqGSEA", mustWork=TRUE)
case.pattern <- "^SC"
ctrl.pattern <- "^SN"
case.files <- dir(dat.dir, pattern=case.pattern, full.names = TRUE)
control.files <- dir(dat.dir, pattern=ctrl.pattern, full.names = TRUE)

## Not run:

RCS <- loadExonCountData(case.files, control.files)
RCS

## End (Not run)
```

loadGenesets

Load gene sets from files

Description

This function is to load annotation of gene sets from files. The files are in the format of Molecular Signatures Database (MSigDB), and those files can be downloaded at <http://www.broadinstitute.org/gsea/msigdb/index.jsp>.

Usage

```
loadGenesets(geneset.file, geneIDs, geneID.type = c("gene.symbol", "ensembl"),
             geneset.size.min = 5, geneset.size.max = 1000)
```

Arguments

geneset.file	the file containing the gene set annotation.
geneIDs	gene IDs that have expression values in the studied data set.
geneID.type	indicating the type of gene IDs, gene symbol or emsembl gene IDs.
geneset.size.min	the minimum number of genes in a gene set that will be treated in the analysis.

genesetsize.max

the maximum number of genes in a gene set that will be treated in the analysis.

Details

TBA

Value

A SeqGeneSet object.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[newGeneSets](#), [SeqGeneSet-class](#)

Examples

```
data(RCS_example, package="SeqGSEA")
geneIDs <- geneID(RCS_example)
geneID.type <- "ensembl"
geneset.file <- system.file("extdata", "gs_symb.txt", package="SeqGSEA", mustWork=TRUE)
##
GS <- loadGenesets(geneset.file, geneIDs, geneID.type = geneID.type)
GS
## end
```

newGeneSets

Initialize a new SeqGeneSet object

Description

This is an internal function to generate a new SeqGeneSet object.

Usage

```
newGeneSets(GS, GSNames, GSDescs, geneList, name = NA_character_,
            sourceFile = NA_character_, GSSizeMin = 5, GSSizeMax = 1000)
```

Arguments

GS	a list, each element is an integer vector, indicating the indexes of genes in each gene set. See <i>Details</i> below.
GSNames	a character string vector, each is the name of each gene set.
GSDescs	a character string vector, each is the description of each gene set.
geneList	a character string vector of gene IDs. See <i>Details</i> below.
name	the name of this category of gene sets.
sourceFile	the source file name of this category of gene sets.
GSSizeMin	the minimum number of genes in a gene set to be analyzed. Default: 5
GSSizeMax	the maximum number of genes in a gene set to be analyzed. Default: 1000

Details

TBA

Value

A SeqGeneSet object.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[loadGenesets](#), [SeqGeneSet-class](#)

Examples

```
##
gs <- newGeneSets(GS=list(1:10, 6:15, 11:20),
                  geneList=paste("Gene", 1:22, sep=""),
                  GSNames=c("gs1", "gs2", "gs3"),
                  GSDescs=c("test1", "test2", "test3"),
                  name="gs examples")

gs
## End
```

newReadCountSet	<i>Generate a new ReadCountSet object</i>
-----------------	---

Description

This is an internal function to generate a new ReadCountSet object.

Usage

```
newReadCountSet(readCounts, exonIDs, geneIDs)
```

Arguments

readCounts	a data frame, read counts for each exon of each samples. Must have colnames, which indicate the label of samples.
exonIDs	a character vector indicating exon IDs.
geneIDs	a character vector indicating gene IDs.

Value

A object of the ReadCountSet class.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[loadExonCountData](#), [ReadCountSet-class](#)

Examples

```
rcounts <- cbind(t(sapply(1:10, function(x) {rnbinom(5, size=10, prob=runif(1))} ) ) ,
                t(sapply(1:10, function(x) {rnbinom(5, size=10, prob=runif(1))} ) ) )
colnames(rcounts) <- c(paste("S", 1:5, sep=""), paste("C", 1:5, sep=""))
geneIDs <- c(rep("G1", 4), rep("G2", 6))
exonIDs <- c(paste("E", 1:4, sep=""), paste("E", 1:6, sep=""))
##
RCS <- newReadCountSet(rcounts, exonIDs, geneIDs)
RCS
## End
```

normES	<i>Normalize enrichment scores</i>
--------	------------------------------------

Description

This is an internal function to normalize enrichment scores. For advanced users only.

Usage

```
normES(gene.set)
```

Arguments

gene.set a SeqGeneSet object after running [calES](#) and [calES.perm](#).

Value

A SeqGeneSet object with ES scores normalized.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[GSEnrichAnalyze](#), [signifES](#)

normFactor	<i>Get normalization factors for normalization DE or DS scores</i>
------------	--

Description

Get normalization factors from permutation scores for normalization DE or DS scores

Usage

```
normFactor(permStat)
```

Arguments

permStat a matrix of NB-statistics from permutation data sets, with row corresponding to genes and columns to permutations.

Value

A vector of normalization factors, each for one gene.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. *BMC Bioinformatics*, 14(Suppl 5):S16.

See Also

[scoreNormalization](#)

Examples

```
data(RCS_example, package="SeqGSEA")
permuteMat <- genpermuteMat(RCS_example, times=10)
RCS_example <- exonTestability(RCS_example)
RCS_example <- estiExonNBstat(RCS_example)
RCS_example <- estiGeneNBstat(RCS_example)
RCS_example <- DSpermute4GSEA(RCS_example, permuteMat)
## (not run)
DSscore.normFac <- normFactor(RCS_example@permute_NBstat_gene)
DSscore <- scoreNormalization(RCS_example@featureData_gene$NBstat, DSscore.normFac)
DSscore.perm <- scoreNormalization(RCS_example@permute_NBstat_gene, DSscore.normFac)
## End (not run)
```

plotES

Plot the distribution of enrichment scores

Description

This function is to plot the distribution of enrichment scores, with comparison with permutation enrichment scores.

Usage

```
plotES(gene.set, pdf = NULL)
```

Arguments

gene.set a SeqGeneSet object after running [GSEnrichAnalyze](#).

pdf whether to save the plot to PDF file; if yes, provide the name of the PDF file.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[GSEnrichAnalyze](#), [plotSigGeneSet](#)

Examples

```
data(DEscore, package="SeqGSEA")
data(DSscore, package="SeqGSEA")
gene.score <- geneScore(DEscore, DSscore, method="linear", DEweight = 0.3)
data(DEscore.perm, package="SeqGSEA")
data(DSscore.perm, package="SeqGSEA")
gene.score.perm <- genePermuteScore(DEscore.perm, DSscore.perm, method="linear", DEweight=0.3)
data(GS_example, package="SeqGSEA")
GS_example <- GSEnrichAnalyze(GS_example, gene.score, gene.score.perm)
plotES(GS_example)
```

plotGeneScore	<i>Plot gene (DE/DS) scores</i>
---------------	---------------------------------

Description

This function is to plot gene scores, as well as DE scores and DS scores

Usage

```
plotGeneScore(score, perm.score = NULL, pdf = NULL,
              main = c("Overall", "Expression", "Splicing"))
```

Arguments

score	the gene/DE/DS score vector.
perm.score	a matrix of the corresponding gene/DE/DS scores on the permutation data sets.
pdf	if a PDF file name provided, plot will be save to that file.
main	the key words representing the type of scores that will be shown in the plot main title.

Details

The plot shows the ranked scores from the largest to the smallest. Lines also show the maximum and average scores, values shown on the top left.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

Examples

```
data(DEscore, package="SeqGSEA")
plotGeneScore(DEscore, main="Expression")
data(DSscore, package="SeqGSEA")
gene.score <- geneScore(DEscore, DSscore, method="linear", DEweight = 0.3)
plotGeneScore(gene.score)
```

plotSig

Plot showing SeqGeneSet's p-values/FDRs vs. NESs

Description

The function is to generate a plot of p-values (FDRs) versus normalized enrichment scores (NES). It also shows the distribution of p-values (FDRs) in this gene set category.

Usage

```
plotSig(gene.set, pdf = NULL)
```

Arguments

`gene.set` a SeqGeneSet object after running [GSEnrichAnalyze](#).
`pdf` whether to save the plot to PDF file; if yes, provide the name of the PDF file.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[GSEnrichAnalyze](#), [plotSigGeneSet](#)

Examples

```
data(DEscore, package="SeqGSEA")
data(DSscore, package="SeqGSEA")
gene.score <- geneScore(DEscore, DSscore, method="linear", DEweight = 0.3)
data(DEscore.perm, package="SeqGSEA")
data(DSscore.perm, package="SeqGSEA")
gene.score.perm <- genePermuteScore(DEscore.perm, DSscore.perm, method="linear", DEweight=0.3)
data(GS_example, package="SeqGSEA")
GS_example <- GSEnrichAnalyze(GS_example, gene.score, gene.score.perm)
plotSig(GS_example)
```

plotSigGeneSet	<i>Plot gene set details</i>
----------------	------------------------------

Description

This function is to generate a two-panel plot showing detailed information of the gene set specified. One panel is showing the running enrichment scores and the position where the ES appear. The other panel shows the significance level of the ES, comparing with permutation ESs.

Usage

```
plotSigGeneSet(gene.set, i, gene.score, pdf = NULL)
```

Arguments

gene.set	a SeqGeneSet object after running GSEnrichAnalyze .
i	the i-th gene set in the SeqGeneSet object. topGeneSets is useful to find the most significantly overrepresented gene set.
gene.score	the gene score vector containing gene scores for each gene.
pdf	whether to save the plot to PDF file; if yes, provide the name of the PDF file.

Details

See [writeSigGeneSet](#), which writes the detailed gene set information to a file or to the screen.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[GSEnrichAnalyze](#), [topGeneSets](#), [plotSig](#), [plotES](#), [writeSigGeneSet](#)

Examples

```
data(DEscore, package="SeqGSEA")
data(DSscore, package="SeqGSEA")
gene.score <- geneScore(DEscore, DSscore, method="linear", DEweight = 0.3)
data(DEscore.perm, package="SeqGSEA")
data(DSscore.perm, package="SeqGSEA")
gene.score.perm <- genePermuteScore(DEscore.perm, DSscore.perm, method="linear", DEweight=0.3)
data(GS_example, package="SeqGSEA")
GS_example <- GSEnrichAnalyze(GS_example, gene.score, gene.score.perm)
topGeneSets(GS_example, n=5)
plotSigGeneSet(GS_example, 9, gene.score) # 9th gene set is the most significant one.
```

rankCombine	<i>Integration of differential expression and differential splice scores with a rank-based strategy</i>
-------------	---

Description

Integration of differential expression and differential splice scores with a rank-based strategy, which simultaneously integrates observed scores and permutation scores using the same ranks.

Usage

```
rankCombine(DEscore, DSscore, DEscoreMat, DSscoreMat, DEweight = 0.5)
```

Arguments

DEscore	differential expression scores, normalized.
DSscore	differential splice scores, normalized.
DEscoreMat	differential expression scores in permuted data sets, normalized.
DSscoreMat	differential splice scores in permuted data sets, normalized.
DEweight	any number between 0 and 1 (included), the weight of differential expression scores (so the weight for differential splice is (1-DEweight)).

Details

This integration method is also known as integration with global ranks. See Wang and Cairns (2013) for details.

Value

A list with two elements `geneScore` and `genePermuteScore`.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. *BMC Bioinformatics*, 14(Suppl 5):S16.

See Also

[geneScore](#), [genePermuteScore](#)

Examples

```

data(DEscore, package="SeqGSEA")
data(DSscore, package="SeqGSEA")
data(DEscore.perm, package="SeqGSEA")
data(DSscore.perm, package="SeqGSEA")
combine <- rankCombine(DEscore, DSscore, DEscore.perm, DSscore.perm, DEweight=0.3)
gene.score <- combine$geneScore
gene.score.perm <- combine$genePermuteScore

```

RCS_example

ReadCountSet object example

Description

An exemplified ReadCountSet object to demonstrate functions in the SeqGSEA package. This object is comprised of 20 samples across 5,000 exons, a part of the prostate cancer RNA-Seq data set from Kannan et al (2011). Please note that the count data in this example object is incomplete.

Usage

```
data("RCS_example")
```

References

Kannan, K., Wang, L., Wang, J., Ittmann, M. M., Li, W., and Yen, L. (2001). Recurrent chimeric RNAs enriched in human prostate cancer identified by deep sequencing. *Proc Natl Acad Sci USA*, 108(22): 9172-7.

ReadCountSet-class

Class "ReadCountSet"

Description

ReadCountSet class

Objects from the Class

Objects can be created by calls of the form [newReadCountSet](#).

Slots

`featureData_gene`: Object of class "data.frame". Data for each genes.

`permute_NBstat_exon`: Object of class "matrix". NB statistics of exons on the permutation data sets.

`permute_NBstat_gene`: Object of class "matrix". NB statistics of genes on the permutation data sets.

`assayData`: Object of class "AssayData". The read count data.

`phenoData`: Object of class "AnnotatedDataFrame". Data for each samples.

`featureData`: Object of class "AnnotatedDataFrame". Data for each exons.

`experimentData`: Object of class "MIAXE". Experiment data.

`annotation`: Object of class "character". Not used.

`protocolData`: Object of class "AnnotatedDataFrame". Protocol information.

`.__classVersion__`: Object of class "Versions". Version information.

Methods

counts Get counts from a ReadCountSet object. See [counts](#).

counts<- Set counts to a ReadCountSet object. See [counts](#).

Extends

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

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. *BMC Bioinformatics*, 14(Suppl 5):S16.

See Also

[newReadCountSet](#), [loadExonCountData](#), [exonID](#), [geneID](#), [counts-methods](#), [label](#), [subsetByGenes](#)

Examples

```
showClass("ReadCountSet")
```

`runDESeq`*Run DESeq for differential expression analysis*

Description

This function provides a wrapper to run DESeq for differential expression analysis. It includes two steps, `DESeq::estimateSizeFactors` and `DESeq::estimateDispersions`.

Usage

```
runDESeq(geneCounts, label)
```

Arguments

`geneCounts` a matrix containing read counts for each gene, can be the output of [getGeneCount](#).
`label` the sample classification labels.

Value

A `CountDataSet` object with size factors and dispersion parameters been estimated.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Anders, S. and Huber, W. (2010) Differential expression analysis for sequence count data, *Genome Biol*, 11, R106.

See Also

[getGeneCount](#), [DENBTest](#), [DENBStat4GSEA](#)

Examples

```
data(RCS_example, package="SeqGSEA")
geneCounts <- getGeneCount(RCS_example)
label <- label(RCS_example)
DEG <- runDESeq(geneCounts, label)
```

scoreNormalization *Normalization of DE/DS scores*

Description

Normalization of DE/DS scores or permutation DE/DS scores.

Usage

```
scoreNormalization(scores, norm.factor)
```

Arguments

`scores` a vector (a nX1 matrix) of a matrix of scores, rows corresponding to genes and columns corresponding to a study or permutation.

`norm.factor` normalization factor, output of the function [normFactor](#).

Value

A normalized vector or matrix depending on the input: with the same dimensions as the input.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. *BMC Bioinformatics*, 14(Suppl 5):S16.

See Also

[normFactor](#)

Examples

```
data(RCS_example, package="SeqGSEA")
permuteMat <- genpermuteMat(RCS_example, times=10)
RCS_example <- exonTestability(RCS_example)
RCS_example <- estiExonNBstat(RCS_example)
RCS_example <- estiGeneNBstat(RCS_example)
RCS_example <- DSpermute4GSEA(RCS_example, permuteMat)
## (not run)
DSscore.normFac <- normFactor(RCS_example@permute_NBstat_gene)
DSscore <- scoreNormalization(RCS_example@featureData_gene$NBstat, DSscore.normFac)
DSscore.perm <- scoreNormalization(RCS_example@permute_NBstat_gene, DSscore.normFac)
## End (not run)
```

SeqGeneSet-class	Class "SeqGeneSet"
------------------	--------------------

Description

SeqGeneSet class

Objects from the Class

Objects can be created by calls of the function `newGeneSets`.

Slots

name: Object of class "character" the name of this gene set category
sourceFile: Object of class "character" the source file of gene set category
geneList: Object of class "character" the gene ID list indicating genes involved in this GSEA
GS: Object of class "list" a list of gene indexes corresponding to geneList, each element in the list indicating which genes are in each gene set of this SeqGeneSet object
GSNames: Object of class "character". Gene set names.
GSDescs: Object of class "character". Gene set descriptions.
GSSize: Object of class "numeric". Gene set sizes.
GSSizeMin: Object of class "numeric". The minimum gene set size to be analyzed.
GSSizeMax: Object of class "numeric". The maximum gene set size to be analyzed.
GS.Excluded: Object of class "list". Gene sets excluded to be analyzed.
GSNames.Excluded: Object of class "character". Gene set names excluded to be analyzed.
GSDescs.Excluded: Object of class "character". Gene set descriptions excluded to be analyzed.
GSEA.ES: Object of class "numeric". Enrichment scores.
GSEA.ES.pos: Object of class "numeric". The positions where enrichment scores appear.
GSEA.ES.perm: Object of class "matrix". The enrichment scores of the permutation data sets.
GSEA.score.cumsum: Object of class "matrix". Running enrichment scores.
GSEA.normFlag: Object of class "logical". Logical indicating whether GSEA.ES has been normalized.
GSEA.pval: Object of class "numeric". P-values of each gene set.
GSEA.FWER: Object of class "numeric". Family-wise error rate of each gene set.
GSEA.FDR: Object of class "numeric". False discovery rate of each gene set.
version: Object of class "Versions". Version information.

Methods

[Get a sub-list of gene sets, and return a SeqGeneSet object.
show Show basic information of the SeqGeneSet object.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

References

Xi Wang and Murray J. Cairns (2013). Gene Set Enrichment Analysis of RNA-Seq Data: Integrating Differential Expression and Splicing. *BMC Bioinformatics*, 14(Suppl 5):S16.

See Also

[newGeneSets](#), [size](#), [geneSetNames](#), [geneSetDescs](#), [geneSetSize](#)

Examples

```
showClass("SeqGeneSet")
```

signifES

Calculate significance of ESs

Description

This is an internal function to calculate significance of ESs of each gene set. For advanced users only.

Usage

```
signifES(gene.set)
```

Arguments

`gene.set` a GeneSet object after running [normES](#).

Value

A SeqGeneSet object with gene set enrichment significance metrics calculated.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[GSEnrichAnalyze](#), [normES](#)

size	<i>Number of gene sets in a SeqGeneSet object</i>
------	---

Description

This function to get the number of gene sets in a SeqGeneSet object.

Usage

```
size(GS)
```

Arguments

GS an object of class SeqGeneSet.

Details

Gene sets with size less than GSSizeMin or more than GSSizeMax are not included.

Value

The number of gene sets in this SeqGeneSet object.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[SeqGeneSet-class](#), [loadGenesets](#)

Examples

```
data(GS_example, package="SeqGSEA")
size(GS_example)
```

subsetByGenes	<i>Get a new ReadCountSet with specified gene IDs.</i>
---------------	--

Description

Get a new ReadCountSet with specified gene IDs.

Usage

```
subsetByGenes(RCS, genes)
```

Arguments

RCS	a ReadCountSet object.
genes	a list of gene IDs.

Value

This function returns a new ReadCountSet object, with changes in slots assayData, featureData, featureData_gene, and permute_NBstat_exon and permute_NBstat_gene if they have been calculated.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[newReadCountSet](#), [ReadCountSet](#)

Examples

```
data(RCS_example, package="SeqGSEA")
RCS_example
genes <- c("ENSG00000000938", "ENSG00000000005")
RCS_sub <- subsetByGenes(RCS_example, genes)
RCS_sub
```

topDEGenes	<i>Extract top differentially expressed genes.</i>
------------	--

Description

This function is to extract top n differentially expressed genes, ranked by either DESeq p-values, DESeq adjusted p-values, permutation p-values, permutation adjusted p-values, or NB-statistics.

Usage

```
topDEGenes(DEGres, n = 20,  
           sortBy = c("padj", "pval", "perm.pval", "perm.padj", "NBstat", "foldChange"))
```

Arguments

DEGres	DE analysis results.
n	the number of top DE genes.
sortBy	indicating which method to rank genes.

Details

If the sortBy method is not among the column names, the function will result in an error.

Value

A table for top n DE genes with significance metrics.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[topDSGenes](#), [topDSExons](#)

Examples

```
data(RCS_example, package="SeqGSEA")  
geneCounts <- getGeneCount(RCS_example)  
label <- label(RCS_example)  
DEG <- runDESeq(geneCounts, label)  
permuteMat <- genpermuteMat(RCS_example, times=10)  
DEGres <- DENBTest(DEG)  
DEpermNBstat <- DENBStatPermut4GSEA(DEG, permuteMat)  
DEGres <- DEpermutePval(DEGres, DEpermNBstat)  
topDEGenes(DEGres, n = 10, sortBy = "NBstat")
```

topDSExons	<i>Extract top differentially spliced exons</i>
------------	---

Description

This function is to extract top n differentially spliced exons, ranked by p-values or NB-stats.

Usage

```
topDSExons(RCS, n = 20, sortBy = c("pvalue", "NBstat"))
```

Arguments

RCS	a ReadCountSet object after running DSpermutePval .
n	the number of top genes.
sortBy	indicating whether p-value or NBstat to be used for ranking genes.

Value

A table for top n exons. Columns include: geneID, exonID, testable, NBstat, pvalue, padjust, and meanCounts.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[topDSGenes](#), [DSpermutePval](#)

Examples

```
data(RCS_example, package="SeqGSEA")
permuteMat <- genpermuteMat(RCS_example, times=10)
RCS_example <- exonTestability(RCS_example)
RCS_example <- estiExonNBstat(RCS_example)
RCS_example <- estiGeneNBstat(RCS_example)
RCS_example <- DSpermutePval(RCS_example, permuteMat)
topDSExons(RCS_example, 10, "NB")
```

topDSGenes	<i>Extract top differentially spliced genes</i>
------------	---

Description

This function to extract top n differentially spliced genes, ranked by p-values or NBstats.

Usage

```
topDSGenes(RCS, n = 20, sortBy = c("pvalue", "NBstat"))
```

Arguments

RCS	a ReadCountSet object after running DSpermutePval .
n	the number of top genes.
sortBy	indicating whether p-value or NBstat to be used for ranking genes.

Value

A table for top n genes. Columns include: geneID, NBstat, pvalue, and padjust.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[topDSExons](#), [DSpermutePval](#)

Examples

```
data(RCS_example, package="SeqGSEA")
permuteMat <- genpermuteMat(RCS_example, times=10)
RCS_example <- exonTestability(RCS_example)
RCS_example <- estiExonNBstat(RCS_example)
RCS_example <- estiGeneNBstat(RCS_example)
RCS_example <- DSpermutePval(RCS_example, permuteMat)
topDSGenes(RCS_example, 10, "NB")
```

topGeneSets	<i>Extract top significant gene sets</i>
-------------	--

Description

This function is to extract n top significant gene sets overrepresented in the samples studied, ranked by FDR, p-values, or FWER.

Usage

```
topGeneSets(gene.set, n = 20, sortBy = c("FDR", "pvalue", "FWER"), GSDesc = FALSE)
```

Arguments

gene.set	an object of class SeqGeneSet after GSEA runs.
n	the number of top gene sets.
sortBy	indicating which method to rank gene sets.
GSDesc	logical indicating whether or not to output gene set descriptions.

Value

A data frame for top n gene sets detected with respect to the ranking method specified. Information includes: GSName, GSSize, ES, ES.pos, pval, FDR, and FWER.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[GSEnrichAnalyze](#), [GSEaresultTable](#)

Examples

```
data(DEscore, package="SeqGSEA")
data(DSscore, package="SeqGSEA")
gene.score <- geneScore(DEscore, DSscore, method="linear", DEweight = 0.3)
data(DEscore.perm, package="SeqGSEA")
data(DSscore.perm, package="SeqGSEA")
gene.score.perm <- genePermuteScore(DEscore.perm, DSscore.perm, method="linear", DEweight=0.3)
data(GS_example, package="SeqGSEA")
GS_example <- GSEnrichAnalyze(GS_example, gene.score, gene.score.perm)
topGeneSets(GS_example, n=5)
```

writeScores	<i>Write DE/DS scores and gene scores</i>
-------------	---

Description

This function is to write DE and DS scores, and optionally gene scores.

Usage

```
writeScores(DEscore, DSscore, geneScore=NULL, geneScoreAttr=NULL, file="")
```

Arguments

DEscore	normalized DE scores.
DSscore	normalized DS scores.
geneScore	gene scores integrated from DE and DS scores.
geneScoreAttr	the parameters for integrating DE and DS scores.
file	output file name, if not specified print to screen.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

[DEscore](#), [geneScore](#)

Examples

```
data(DEscore, package="SeqGSEA")
data(DSscore, package="SeqGSEA")
gene.score <- geneScore(DEscore, DSscore, method="linear", DEweight = 0.3)
writeScores(DEscore, DSscore) # without gene scores
writeScores(DEscore, DSscore, geneScore = gene.score,
            geneScoreAttr = "linear,0.3") # gene scores with attr.
```

writeSigGeneSet	<i>Write gene set supporting information</i>
-----------------	--

Description

This function is to write the specified gene set (whose index is *i*) with significance information, including p-value and FDR, and gene scores for each gene in this set.

Usage

```
writeSigGeneSet(gene.set, i, gene.score, file = "")
```

Arguments

<code>gene.set</code>	an object of class <code>SeqGeneSet</code> with <code>GSEnrichAnalyze</code> done.
<code>i</code>	the <i>i</i> -th gene set in the <code>SeqGeneSet</code> object. <code>topGeneSets</code> is useful to find the most significantly overrepresented gene set.
<code>gene.score</code>	the vector of gene scores for running GSEA.
<code>file</code>	output file name, if not specified print to screen.

Details

See `plotSigGeneSet`, which shows graphic information of the gene set specified.

Author(s)

Xi Wang, xi.wang@newcastle.edu.au

See Also

`GSEnrichAnalyze`, `topGeneSets`, `plotSigGeneSet`

Examples

```
data(DEscore, package="SeqGSEA")
data(DSscore, package="SeqGSEA")
gene.score <- geneScore(DEscore, DSscore, method="linear", DEweight = 0.3)
data(DEscore.perm, package="SeqGSEA")
data(DSscore.perm, package="SeqGSEA")
gene.score.perm <- genePermuteScore(DEscore.perm, DSscore.perm, method="linear", DEweight=0.3)
data(GS_example, package="SeqGSEA")
GS_example <- GSEnrichAnalyze(GS_example, gene.score, gene.score.perm)
topGeneSets(GS_example, n=5)
writeSigGeneSet(GS_example, 9, gene.score) # 9th gene set is the most significant one.
```


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