Package ‘rgsepd’
December 22, 2016

Type Package
Title Gene Set Enrichment / Projection Displays
Version 1.6.0
Date 2016-04-02
Author Karl Stamm
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Description R/GSEPD is a bioinformatics package for R to help
disambiguate transcriptome samples (a matrix of RNA-Seq counts
at RefSeq IDs) by automating differential expression (with
DESeq2), then gene set enrichment (with GOSeq), and finally a
N-dimensional projection to quantify in which ways each sample
is like either treatment group.
Depends R (>= 3.3.0), DESeq2, goseq (>= 1.17)
Imports gplots, biomaRt, org.Hs.eg.db, GO.db, SummarizedExperiment,
hash, AnnotationDbi
Suggests boot, tools, RUnit, BiocGenerics, knitr, xtable
License GPL-3
biocViews Software, DifferentialExpression, GeneSetEnrichment, RNASeq
VignetteBuilder knitr
NeedsCompilation no

R topics documented:

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Description

R/GSEPD is a Bioinformatics package for the R programming environment that helps you disambiguate transcriptome samples (Human RNA-Seq at RefSeq IDs) by automating differential expression (DESeq), then gene set enrichment (GOSeq hg19), and finally a N-dimensional projection to quantify in which ways each sample is like either treatment group. Many exploratory tables and plots are generated for you to browse the behavior of your samples in various gene-sets (defined by GO). Sets which significantly segregate your sample conditions by bootstrapped k-means are further explored.

See the Vignette for usage examples, and minimal examples within each function’s reference.

Details

Package: rgsepd
Type: Package
Version: 0.99.9
Date: 2014-11-21
License: GPL-3

Author(s)

Karl D. Stamm <karl.stamm@gmail.com>

References

Wrapper for DESeq2 and GOSeq.

See Also

Example data is public human RNA-Seq from Illumina Human Bodymap2 project, aligned to GRCh37 by Ensembl and downloaded from ftp://ftp.ensembl.org/pub/release-70/bam/homo_sapiens/genebuild/ then read counts are collected by coverageBed using RefSeq.GTF. We downloaded Adipose,Blood,Heart and Skeletal Muscle, and downsampled each to one third to create artificial replicates.

See the Vignette for usage walkthrough and results summaries.

Examples

data("IlluminaBodymap")
data("IlluminaBodymapMeta")
set.seed(1000) #fixed randomness
isoform_ids <- Name_to_RefSeq(c("HIF1A","EGFR","MYH7","CD33","BRCA2"))
rows_of_interest <- unique( c( isoform_ids ,
sample(rownames(IlluminaBodymap),
size=500,replace=FALSE)))
G <- GSEPD_INIT(Output_Folder="OUT",
finalCounts=round(IlluminaBodymap[rows_of_interest , ]),
sampleMeta=IlluminaBodymapMeta,
COLORS=c("green","black","red"))
G <- GSEPD_ChangeConditions( G, c("A","B"))
# G <- GSEPD_Process( G ) #would run DESeq2 and GOSeq and GSEPD comparing conditions A and B

<table>
<thead>
<tr>
<th>DisplayName</th>
<th>DisplayName</th>
</tr>
</thead>
</table>

**Description**

Convert a NM## id number to the corresponding HGNC Gene name, where available.

**Usage**

`DisplayName(NM)`

**Arguments**

`NM` The NM_### id number, or a vector thereof.

**Value**

The gene’s human-readable name.

**Note**

Uses org.Hs.eG.db and pulls the first Entrez Gene ID, then that ID’s associated HGNC.

**Examples**

`DisplayName("NM_005228")`
GSEPD_ChangeConditions

Description
This function is an interface to set which samples are the test conditions. Don’t forget to GSEPD_Process() after changing settings. If you want to systematically try each condition pairing, try GSEPD_ProcessAll()

Usage
GSEPD_ChangeConditions(GSEPD, newConditions)

Arguments
GSEPD Parameters object.
newConditions a two-item vector matching some of your sampleMeta$Conditions

Details
Interface will check if the conditions are known, then set the C2T value.

Value
Returns the GSEPD parameter object with its mode set via the C2T and Conditions element of the named list. These tell later steps which sample conditions you intend on comparing.

See Also
GSEPD_Example

Examples
data("IlluminaBodymap")
data("IlluminaBodymapMeta")
set.seed(1000) #fixed randomness
isoform_ids <- Name_to_RefSeq(c("HIF1A","EGFR","MYH7","CD33","BRCA2"))
rows_of_interest <- unique( c( isoform_ids , sample(rownames(IlluminaBodymap), size=500,replace=FALSE)))
G <- GSEPD_INIT(Output_Folder="OUT", finalCounts=round(IlluminaBodymap[rows_of_interest , ]), sampleMeta=IlluminaBodymapMeta, COLORS=c("green","black","red"))
ConditionsToTest <- c("A","B")
G <- GSEPD_ChangeConditions( G, ConditionsToTest )
#G <- GSEPD_Process( G ) #would test samples A vs samples B
G <- GSEPD_ChangeConditions( G, c("A","C"))
#G <- GSEPD_Process( G ) #would test samples A vs samples C
Description

Update the stored output folder designation, and create it if necessary. This is useful if you want to change some LIMIT parameters and re-run the pipeline. Don’t forget to GSEPD_Process() after changing settings.

Usage

GSEPD_ChangeOutput(GSEPD, newFolder)

Arguments

GSEPD The initial GSEPD parameter object to update the output folder of.
newFolder The new output folder to be created.

Value

Returns the updated GSEPD parameter object.

Author(s)

karl.stamm@gmail.com

Examples

data("IlluminaBodymap")
data("IlluminaBodymapMeta")
set.seed(1000) #fixed randomness
isoform_ids <- Name_to_RefSeq(c("HIF1A","EGFR","MYH7","CD33","BRCA2"))
rows_of_interest <- unique( c(isoform_ids, sample(rownames(IlluminaBodymap), size=500, replace=FALSE)))
G <- GSEPD_INIT(Output_Folder="OUT", finalCounts=round(IlluminaBodymap[rows_of_interest , ], sampleMeta=IlluminaBodymapMeta, COLORS=c("green","black","red"))
G <- GSEPD_ChangeConditions( G, c("A","B")) #set testing groups first!
G<- GSEPD_ChangeOutput(G, "Output2")
#G <- GSEPD_Process( G ) #would output to folder Output2
#now tweak some settings and re-do
G$LIMIT$LFC <- 0.25 #lower than default log-fold-change limit
G<- GSEPD_ChangeOutput(G, "Output-Low")
#G <- GSEPD_Process( G ) #would output to folder Output-Low
**GSEPD_DEGHeatmap**

**Differentially Expressed Genes Heatmap**

**Description**

Generates a gene-by-subject heatmap plot of differentially expressed genes.

**Usage**

`GSEPD_DEGHeatmap(G)`

**Arguments**

- **G**
  
  The GSEPD master object carries sample information and gene expression data. It should have already run Process() to be eligible. Parameters regarding differential expression limits are set within the GS$LIMIT list object.

**Details**

After GSEPD_Process() has created differential expression tables with known filenames, this function can read those tables and make heatmap plots for a subset of genes. We use the N most significant genes, specified by the `MAX_Genes_for_Heatmap` parameter of the passed GSEPD object.

**Value**

This function doesn’t return anything. If successful, four PDF files are created. HM and HM- are all subjects from sampleMeta and finalCounts, HMS and HMS- are only those in the test groups. The hyphen indicates a smaller unlabeled figure. In each case the data is manipulated as in GSEPD_Heatmap() such that complete linkage clustering is performed on z-score normalized genes using the normalized counts directly from DESeq2::varianceStabilizingTransformation, which are displayed in the labeled figures.

**Examples**

```r
data("IlluminaBodymap")
data("IlluminaBodymapMeta")
set.seed(1000) #fixed randomness
isoform_ids <- Name_to_RefSeq(c("HIF1A","EGFR","MYH7","CD33","BRCA2"))
rows_of_interest <- unique(c(isoform_ids,
                            sample(rownames(IlluminaBodymap),
                                   size=500,replace=FALSE)))
G <- GSEPD_INIT(Output_Folder="OUT",
            finalCounts=round(IlluminaBodymap[rows_of_interest , ]),
            sampleMeta=IlluminaBodymapMeta,
            COLORS=c("green","black","red"))
G <- GSEPD_ChangeConditions( G, c("A","B")) #set testing groups first!
G <- GSEPD_Process( G ) #have to have processed results to plot them
GSEPD_DEGHeatmap(G) # all parameters automatic```
Description

Converts from the internal matrices to a DESeq standard object.

Usage

GSEPD_Export_DESeq(G)

Arguments

G

The GSEPD list object to extract a DeseqDataSet from.

Details

Using the given GSEPD object’s finalCounts and sampleMeta, a simple DESeqDataSet object is created with the default design matrix. Provided for interoperability with other analysis packages.

Value

an object of class DESeqDataSet

References

DESeq2

Examples

data("IlluminaBodymap")
data("IlluminaBodymapMeta")
set.seed(1000) #fixed randomness
isoform_ids <- Name_to_RefSeq(c("HIF1A","EGFR","MYH7","CD33","BRCA2"))
rows_of_interest <- unique(c(isoform_ids ,
sample(rownames(IlluminaBodymap),
size=500,replace=FALSE)))
G <- GSEPD_INIT(Output_Folder="OUT",
finalCounts=round(IlluminaBodymap[rows_of_interest , ]),
sampleMeta=IlluminaBodymapMeta,
COLORS=c("green","black","red"))
G <- GSEPD_ChangeConditions( G, c("A","B")) #set testing groups first!
dds <- GSEPD_Export_DESeq(G)
print(dds)
GSEPD_Heatmap

Description
Plots the heatmap to the standard display. Uses heatmap.2 from gplots to display selected genes’ expression level.

Usage
GSEPD_Heatmap(G, genes, cap_range=3, cellnote="log10")

Arguments
- **G**: The GSEPD parameter object. Must be post Process.
- **genes**: rownames of finalCounts, usually isoform ID#s.
- **cap_range**: z-score of most extreme color
- **cellnote**: display the log10 values in each cell. No other options are supported.

Details
Will use GSEPD$COLORFUNCTION scaled between samples of type GSEPD$Conditions in GSEPD$sampleMeta, including others in the mix. The heatmap’s dendrograms (margin trees) are computed by the heatmap.2() function’s default method hclust() on the supplied data, resulting in complete linkage hierarchical clustering. Because the magnitude of gene expression varies across a wide range, and we’re interested in patterns more than scale, we first normalize each gene(row) by subtracting the mean, dividing by the standard deviation, and capping the min and max to the parameter cap_range=3. The heatmap function is run with no further scaling, ensuring genes with similar differential expression profiles are clustered together. The numbers written in each cell of the heatmap are simply the normalized counts directly from DESeq2::varianceStabilizingTransformation.

Value
No return value: generates a figure.

Examples
```r
data("IlluminaBodymap")
data("IlluminaBodymapMeta")
set.seed(1000) #fixed randomness
isoform_ids <- Name_to_RefSeq(c("HIF1A","EGFR","MYH7","CD33","BRCA2"))
rows_of_interest <- unique( c( isoform_ids ,
sample(rownames(IlluminaBodymap),
size=500,replace=FALSE)))
G <- GSEPD_INIT(Output_Folder="OUT",
finalCounts=round(IlluminaBodymap[rows_of_interest , ]),
sampleMeta=IlluminaBodymapMeta,
COLORS=c("green","black","red"))
G <- GSEPD_ChangeConditions( G, c("A","B")) #set testing groups first!
G <- GSEPD_Process( G ) #have to have processed results to plot them```
**GSEPD_INIT**

GSEPD_Heatmap(G, genes=sample(rownames(G$finalCounts),8) )

---

### Initialization

**Description**

Initializes the system, here you will pass in the count dataset and the sample metadata, before any GSEPD processing. Return value is a named list holding configurable parameters.

**Usage**

```r
GSEPD_INIT(Output_Folder = "OUT", finalCounts = NULL, sampleMeta = NULL,
DESeqDataSet = NULL,
COLORS = c("green", "gray", "red"),
C2T = "x" )
```

**Arguments**

- **Output_Folder**: Specify the subdirectory to hold output/generated files. Defaults to "OUT".
- **finalCounts**: This must be a matrix of count data, rows are transcript IDs and columns are samples.
- **sampleMeta**: The sampleMeta matrix must be passed here. It is a data frame with a row for each sample in the finalCounts matrix. Some required columns are SHORT-NAME= sample nicknames; Condition= treatment group for differential expression; and Sample are the column names of finalCounts. Other columns are permitted to facilitate subsetting (not automatically supported).
- **DESeqDataSet**: Data may also be included in the format of a DESeqDataSet object, this is mutually exclusive of the finalCounts/sampleMeta scheme.
- **COLORS**: A three element vector of colors to make the heatmaps, the first element is the under-expressed genes, and the third element is the over-expressed genes. Defaults to green-red through gray.
- **C2T**: This symbol is used in the filenames to delimit sample groups.

**Details**

This function sets up the master parameter object, and therefore must be called first. This object includes all configurable parameters you can change before running the pipeline. Count data should be provided in the finalCounts matrix, with phenotype and sample data in the sampleMeta matrix. Optionally, these data may be packages in a DESeqDataSet instead. Rows with no expression are dropped at the point of loading.

**Value**

Returns the GSEPD named list master object, to be used in subsequent function calls.

**See Also**

GSEPD_Process
**Examples**

data("IlluminaBodymap")
data("IlluminaBodymapMeta")
isoform_ids <- Name_to_RefSeq(c("HIF1A", "EGFR", "MYH7", "CD33", "BRCA2"))
rows_of_interest <- unique(c(isoform_ids, sample(rownames(IlluminaBodymap), size=1000, replace=FALSE)))
G <- GSEPD_INIT(Output_Folder="OUT", finalCounts=round(IlluminaBodymap[rows_of_interest , ]), sampleMeta=IlluminaBodymapMeta, COLORS=c("green", "black", "red"))
#now ready to run:
# G<-GSEPD_ProcessAll(G);
G <- GSEPD_ChangeConditions( G, c("A","B")) #set testing groups first!
G <- GSEPD_Process( G ) #have to have processed results to plot them
GSEPD_PCA_Plot(G)

---

**GSEPD_PCA_Spec**

**Specialized PCA Plot**

**Description**

After processing the pipeline, users may want to have further PCA figures generated. This function takes a completed GSEPD object and generates informative figures. This function includes parameters to specify a particular GO-Term of interest.

**Usage**

```r
GSEPD_PCA_Spec(GSEPD, GOT, MDATA = NULL)
```

**Arguments**

- **GSEPD**
  The master GSEPD object, post-processed.
- **GOT**
  The GO-Term you’d like to specifically analyse. It should be found in the .MERGE file.
- **MDATA**
  Optionally, pass in the .MERGE dataset, if missing, we’ll try to read the already-processed file from the output directory. This option exists because reading that file repeatedly is quite slow, so you’re recommended to read it in once in advance if you intend on making more than one GO-Term specific plot.

**Value**

No return value. Generates files.

**Note**

This function uses either princomp() or prcomp() as necessary, depending on sample count vs gene count.

**See Also**

GSEPD_PCA_Plot

**Examples**

```r
data("IlluminaBodymap")
data("IlluminaBodymapMeta")
set.seed(1000) #fixed randomness
isoform_ids <- Name_to_RefSeq(c("HIF1A","EGFR","MYH7","CD33","BRCA2"))
rows_of_interest <- unique( c( isoform_ids ,
 sample(rownames(IlluminaBodymap),
 size=500,replace=FALSE)))
G <- GSEPD_INIT(Output_Folder="OUT",
 finalCounts=round(IlluminaBodymap[rows_of_interest , ]),
```
sampleMeta=IlluminaBodymapMeta,
COLORS=c("green","black","red"))
G <- GSEPD_ChangeConditions( G, c("A","B"))  #set testing groups first!
G <- GSEPD_Process( G )  #have to have processed results to plot them

GOT <- "GO:0012345"  # specify a GO Term you'd like to review

# it should be present in the MERGE file.
MergeFile <- list.files(G$Output_Folder, pattern="MERGE")[1]
MDATA<-read.csv(sprintf("%s%s%s", G$Output_Folder, .Platform$file.sep, MergeFile),
as.is=TRUE,header=TRUE)

GOT=MDATA$category[1]  #choose a GO term that is definitely in the output data.
GSEPD_PCA_Spec(G, GOT, MDATA=MDATA)

---

# GSEPD_Process Processing

## Description

Primary interface, use this function to kick off the pipeline.

## Usage

GSEPD_Process(GSEPD)

## Arguments

- **GSEPD**: The initialized GSEPD master object to operate on.

## Details

Runs the pipeline. If any files are already present matching the generated filenames, they will be reused. If you changed a parameter that would alter the generated filenames, new ones are created. If a customization parameter is not part of the filename (like a p-value cutoff), you should change the output folder to keep new files separate.

## Value

Returns the GSEPD object post-processed, for use in further plotting functions. Optional.

## See Also

- GSEPD_INIT

## Examples

data("IlluminaBodymap")
data("IlluminaBodymapMeta")
set.seed(1000)  #fixed randomness
isoform_ids <- Name_to_RefSeq(c("HIF1A","EGFR","MYH7","CD33","BRCA2"))
rows_of_interest <- unique( c(isoform_ids,
sample(rownames(IlluminaBodymap),
...
GSEPD_ProcessAll

G <- GSEPD_INIT(Output_Folder="OUT", finalCounts=round(IlluminaBodymap[rows_of_interest , ]), sampleMeta=IlluminaBodymapMeta, COLORS=c("green","black","red"))
G <- GSEPD_ChangeConditions( G, c("A","B")) #set testing groups first!
# G <- GSEPD_Process( G ) #would run DESeq2 and GOSeq and GSEPD comparing conditions A and B

Description
Runs each pairing within GSEPD$sampleMeta$Conditions.

Usage
GSEPD_ProcessAll(G)

Arguments
G
The GSEPD object from GSEPD_INIT()

Details
Set your GSEPD$LIMIT before running each pairwise comparison.

Value
Returns the last GSEPD object.

See Also
GSEPD_Process

Examples
data("IlluminaBodymap")
data("IlluminaBodymapMeta")
head(IlluminaBodymap)
set.seed(1000) #fixed randomness
isoform_ids <- Name_to_RefSeq(c("HIF1A","EGFR","MYH7","CD33","BRCA2"))
rows_of_interest <- unique( c( isoform_ids , sample(rownames(IlluminaBodymap), size=50,replace=FALSE)))
G <- GSEPD_INIT(Output_Folder="OUT", finalCounts=round(IlluminaBodymap[rows_of_interest , ]), sampleMeta=IlluminaBodymapMeta, COLORS=c("green","black","red"))
# G <- GSEPD_ProcessAll( G ) #would run across all pairs of G$Condition
GSEPD_PullDEG  

**Pull Differentially Expressed Genes**

**Description**

After processing, if you want to easily access the differentially expressed transcript listing, this function will read in the default generated files, and apply filters as specified by the GSEPD master object (default p-values).

**Usage**

```r
GSEPD_PullDEG(GSEPD, PTHRESH)
```

**Arguments**

- **GSEPD**
  - The master object should have been processed already such that differentially expressed genes are readily available.

- **PTHRESH**
  - Specify the degree of stringency.

**Value**

Returns a vector of ID#, suitable to row-subsetting of the finalCounts table.

**Examples**

```r
data("IlluminaBodymap")
data("IlluminaBodymapMeta")
set.seed(1000) #fixed randomness
isoform_ids <- Name_to_RefSeq(c("HIF1A","EGFR","MYH7","CD33","BRCA2"))
rows_of_interest <- unique( c( isoform_ids , sample(rownames(IlluminaBodymap), size=500,replace=FALSE)))
G <- GSEPD_INIT(Output_Folder="OUT", 
finalCounts=round(IlluminaBodymap[rows_of_interest , ]), sampleMeta=IlluminaBodymapMeta, 
COLORS=c("green","black","red"))
G <- GSEPD_ChangeConditions( G, c("A","B")) #set testing groups first!
G <- GSEPD_Process( G ) #have to have processed results to plot them
Significant_Genes <- GSEPD_PullDEG(G, PTHRESH=0.0250)
#then do more with these identifiers:
print(Significant_Genes)
# GSEPD_Heatmap(G, genes= Significant_Genes )
```
**Description**

A collection of counts datasets from Illumina Human Bodymap 2.0, one sample each for adipose, blood, heart and skeletal_muscle. Four technical replicates are created by downsampling the original Illumina data. Alignment was performed by Ensembl, so the source of this dataset is ftp://ftp.ensembl.org/pub/release-70/bam/homo_sapiens/genebuild. Each of the four Human Bodymap samples are downsamled four times. Read counts are collected with Bedtools CoverageBed and a RefSeq exon annotation.

**Usage**

data(IlluminaBodymap)

**Format**

A data frame with 37653 observations on the following 16 variables.

- adipose.1: Illumina Human Bodymap 2 'Adipose' sample, downsampled to one-third.
- adipose.2: Illumina Human Bodymap 2 'Adipose' sample, downsampled to one-third.
- adipose.3: Illumina Human Bodymap 2 'Adipose' sample, downsampled to one-third.
- adipose.4: Illumina Human Bodymap 2 'Adipose' sample, downsampled to one-third.
- blood.1: Illumina Human Bodymap 2 'Blood' sample, downsampled to one-third.
- blood.2: Illumina Human Bodymap 2 'Blood' sample, downsampled to one-third.
- blood.3: Illumina Human Bodymap 2 'Blood' sample, downsampled to one-third.
- blood.4: Illumina Human Bodymap 2 'Blood' sample, downsampled to one-third.
- heart.1: Illumina Human Bodymap 2 'Heart' sample, downsampled to one-third.
- heart.2: Illumina Human Bodymap 2 'Heart' sample, downsampled to one-third.
- heart.3: Illumina Human Bodymap 2 'Heart' sample, downsampled to one-third.
- heart.4: Illumina Human Bodymap 2 'Heart' sample, downsampled to one-third.
- skeletal_muscle.1: Illumina Human Bodymap 2 'Skeletal Muscle' sample, downsampled to one-third.
- skeletal_muscle.2: Illumina Human Bodymap 2 'Skeletal Muscle' sample, downsampled to one-third.
- skeletal_muscle.3: Illumina Human Bodymap 2 'Skeletal Muscle' sample, downsampled to one-third.
- skeletal_muscle.4: Illumina Human Bodymap 2 'Skeletal Muscle' sample, downsampled to one-third.

**Value**

A numeric matrix of read-counts from RNA-Seq, measured at transcripts by coverageBed.

**Source**

http://www.ebi.ac.uk/arrayexpress/experiments/E-MTAB-513/
IlluminaBodymapMeta

References

Illumina Human Bodymap 2.0. Ensembl etc.

Examples

data(IlluminaBodymap)
head(IlluminaBodymap, 30)

---

### IlluminaBodymapMeta

**Metadata table for the included sample data**

#### Description

The metadata table required to inform GSEPD of the sample/condition and abbreviated names for each column of the included ‘counts’ dataset. You should mirror this table’s structure for your dataset.

#### Usage

data(IlluminaBodymapMeta)

#### Format

A data frame with 16 observations on the following 3 variables.

- **Sample**: A vector of the column names in your counts table, for the included sample data, it’s four tissue types repeated four times each. For your data this must correspond to the column labels in the counts table.

- **Condition**: The sample categorizations for use in differential expression, this should also be a vector the same length as the number of columns in your counts table. Here we have ‘A’ for each Adipose, ‘B’ for each muscle type, and ‘C’ for the blood samples.

- **SHORTNAME**: Abbreviated names for each sample to appear in plots.

#### Value

A dataframe of sample identifiers for the rgsepd::IlluminaBodymap matrix.

#### Examples

data(IlluminaBodymapMeta)
str(IlluminaBodymapMeta)
Description

Lookup a HGNC symbol and return an appropriate NM##.

Usage

\texttt{Name\_to\_RefSeq(x)}

Arguments

\texttt{x} \quad \text{The HGNC symbol(s) you wish to convert.}

Details

Not found gene symbols will return NA or the empty string.

Value

The NM_### id numbers corresponding to the input gene names (HGNC symbols.)

Note

This routine relies on bioconductor annotation package \texttt{org.Hs.eg.db} to ensure the most up to date mappings.

Examples

\texttt{Name\_to\_RefSeq("LSMEM2")}
\texttt{#should return NM_153215}
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