Package 'consICA'

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Type Package

biocViews Technology, StatisticalMethod, Sequencing, RNASeq, Transcriptomics, Classification, FeatureExtraction

Title consensus Independent Component Analysis

Version 1.2.0

Description consICA implements a data-driven deconvolution method – consensus independent component analysis (ICA) to decompose heterogeneous omics data and extract features suitable for patient diagnostics and prognostics.
The method separates biologically relevant transcriptional signals from technical effects and provides information about the cellular composition and biological processes.
The implementation of parallel computing in the package ensures efficient analysis of modern multicore systems.

BugReports https://github.com/biomod-lih/consICA/issues

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Encoding UTF-8

LazyData false

Imports fastICA (>= 1.2.1), sm, org.Hs.eg.db, GO.db, stats, SummarizedExperiment, BiocParallel, graph, methods, pheatmap, survival, topGO, graphics, grDevices

Depends R (>= 4.2.0)

Suggests knitr, BiocStyle, rmarkdown, testthat

VignetteBuilder knitr

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R topics documented:

`consICA` *Calculate consensus Independent Component Analysis*

Description

calculate consensus independent component analysis (ICA)

Usage

```
consICA(
  X,
  ncomp = 10,
  ntry = 1,
  show.every = 1,
  filter.thr = NULL,
  ncores = 1,
  bpparam = NULL,
  reduced = FALSE,
  exclude = TRUE,
  fun = "logcosh",
  alg.typ = "deflation",
```

```
  verbose = FALSE
)
```

Arguments

X	a 'SummarizedExperiment' object. Assay used as data matrix with features in rows and samples in columns. See SummarizedExperiment-class
ncomp	number of components.
ntry	number of consensus runs. Default value is 1
show.every	numeric logging period in iterations (disabled for 'ncore's > 1). Default value is 1
filter.thr	Filter out genes (rows) with values lower than this value from 'X'
ncores	number of cores to be set for parallel calculation. Default value is 1
bpparam	parameters from the 'BiocParallel'
reduced	If TRUE returns reduced result (no 'X', 'i.best', see 'return')
exclude	are samples excluded during multiple run? If TRUE one random sample will be excluded per run. Default is TRUE
fun	the functional form of the G function used in the approximation to neg-entropy in fastICA. Default value is "logcosh"
alg.typ	parameter for fastICA(). If alg.typ == "deflation" the components are extracted one at a time. If alg.typ == "parallel" the components are extracted simultaneously. Default value is "deflation"
verbose	logic TRUE or FALSE. Use TRUE for print process steps. Default value is FALSE

Value

a list with

X	input 'SummarizedExperiment' object
nsamples, nfeatures	dimension of X
S, M	consensus metagene and weight matrix
ncomp	number of components
mr2	mean R2 between rows of M
stab	stability, mean R2 between consistent columns of S in multiple tries. Applicable only for 'ntry' > 1
i.best	number of best iteration

Author(s)

Petr V. Nazarov

See Also

fastICA

Examples

```
data("samples_data")
# Deconvolve into independent components
cica <- consICA(samples_data, ncomp=15, ntry=10, show.every=0)
# X = S * M, where S - independent signals matrix, M - weights matrix
dim(samples_data)
dim(cica$S)
dim(cica$M)
```

---

enrichGO *Enrichment analysis of GO-terms based on Ensembl IDs*

Description

Enrichment analysis of GO-terms for independent components with Ensembl IDs based on topGO package

Usage

```
enrichGO(
  genes,
  fdr = NULL,
  fc = NULL,
  ntop = NA,
  thr.fdr = 0.05,
  thr.fc = NA,
  db = "BP",
  genome = "org.Hs.eg.db",
  id = c("entrez", "alias", "ensembl", "symbol", "genename"),
  algorithm = "weight",
  do.sort = TRUE,
  randomFraction = 0,
  return.genes = FALSE
)
```

Arguments

genes	character vector with list of ENSEBML IDs
fdr	numeric vector of FDR for each gene
fc	numeric vector of logFC for each gene
ntop	number of first taken genes
thr.fdr	significance threshold for FDR

thr.fc	significance threshold for absolute logFC
db	name of GO database: "BP","MF","CC"
genome	R-package for genome annotation used. For human - 'org.Hs.eg.db'
id	id
algorithm	algorithm for 'runTest()'
do.sort	if TRUE - resulted functions sorted by p-value
randomFraction	for testing only, the fraction of the genes to be randomized
return.genes	If TRUE include genes in output. Default value is FALSE

Value

list with terms and stats

Author(s)

Petr V. Nazarov

`estimateVarianceExplained`

Estimate the variance explained by the model

Description

The method estimates the variance explained by the model and by each independent component. We used the coefficient of determination (R2) between the normalized input (X-mean(X)) and (S*M)

Usage

```
estimateVarianceExplained(cica, X = NULL)
```

Arguments

cica	list compliant to 'consICA()' result
X	a 'SummarizedExperiment' object. Assay used for the model. Will be used if consICA$X is NULL, ignore otherwise.

Value

a list of:

R2	total variance explained by the model
R2_ics	Amount of variance explained by the each independent component

Examples

```
data("samples_data")
cica <- consICA(samples_data, ncomp=15, ntry=10, show.every=0)
var_ic <- estimateVarianceExplained(cica)
```

`getFeatures` *Get features from consICA deconvolution result*

Description

Extract names of features (rows in ‘X‘ and ‘S‘ matrices) and their false discovery rates values

Usage

```
getFeatures(cica, alpha = 0.05, sort = FALSE)
```

Arguments

`cica`	list compliant to ‘consICA()‘ result
`alpha`	value in [0,1] interval. Used to filter features with FDR < ‘alpha‘. Default value is 0.05
`sort`	sort features decreasing FDR. Default is FALSE

Value

list of dataframes ‘pos‘ for positive and ‘neg‘ for negative affecting features with columns:

`features`	names of features
`fdr`	false discovery rate value

Author(s)

Petr V. Nazarov

Examples

```
data("samples_data")
# Get deconvolution of X matrix
cica <-  consICA(samples_data, ncomp=10, ntry=1, show.every=0)
# Get features names and FDR for each component
features <- getFeatures(cica)
# Positive affecting features for first components are
ic1_pos <- features$ic.1$pos
```

getGO *Assigns IC signatures to Gene Ontologies*

Description

Assigns extracted independent components to Gene Ontologies and rotate independent components (‘S‘ matrix) to set most significant Gene Ontologies as positive affecting features

Usage

```
getGO(
  cica,
  alpha = 0.05,
  genenames = NULL,
  genome = "org.Hs.eg.db",
  db = c("BP", "CC", "MF"),
  rotate = TRUE
)
```

Arguments

cica	list compliant to ‘consICA()‘ result
alpha	value in [0,1] interval. Used to filter features with FDR < ‘alpha‘. Default value is 0.05
genenames	alternative names of genes. If NULL we use rownames of ‘S‘ matrix. We automatically identify type of gene identifier, you can use Ensembl, Symbol, Entrez, Alias, Genename IDs.
genome	R-package for genome annotation used. For human - ’org.Hs.eg.db’
db	name of GO database: "BP","MF","CC"
rotate	rotate components in ‘S‘ and ‘M‘ matricies in ‘cica‘ object to set most significant Gene Ontologies as positive effective features. Default is TRUE

Value

rotated (if need) ‘cica‘ object with added ‘GO‘ - list for each db chosen (BP, CC, MM), with dataframes ‘pos‘ for positive and ‘neg‘ for negative affecting features for each component:

GO.ID	id of Gene Ontology term
Term	name of term
Annotated	number of annotated genes
Significant	number of significant genes
Expected	estimate of the number of annotated genes if the significant genes would be randomly selected from the gene universe classisFisher F-test
FDR	false discovery rate value
Score	genes score

Author(s)

Petr V. Nazarov

Examples

```
data("samples_data")
# cica <- consICA(samples_data, ncomp=40, ntry=1, show.every=0)
cica <- consICA(samples_data, ncomp=2, ntry=1, show.every=0) # timesaving
example
cica <- getGO(cica, db = "BP")
head(cica$GO$GOBP$ic02$pos)
```

---

get_score *Create score depending on threshold and paradigm*

Description

Create score depending on threshold and paradigm

Usage

```
get_score(genes, fc, thr.fc, fdr, thr.fdr, ntop)
```

Arguments

genes	character vector with list of ENSEBML IDs
fc	numeric vector of logFC for each gene
thr.fc	significance threshold for absolute logFC
fdr	numeric vector of FDR for each gene
thr.fdr	significance threshold for FDR
ntop	number of first taken genes

Value

numeric score vector

is.consICA *Is the object is consensus ICA compliant?*

Description

Check if the object is a list in the same format as the result of 'consICA()'

Usage

```
is.consICA(cica)
```

Arguments

cica	list

Value

TRUE or FALSE

Examples

```
# returns TRUE
is.consICA(list("ncomp" = 2, "nsples" = 2, "nfeatures" = 2,
                "S" = matrix(0,2,2),"M" = matrix(0,2,2)))
```

oneICA *Runs* fastICA

Description

Runs fastICA once and store in a consICA manner

Usage

```
oneICA(
  X,
  ncomp = 10,
  filter.thr = NULL,
  reduced = FALSE,
  fun = "logcosh",
  alg.typ = "deflation"
)
```

Arguments

X	a 'SummarizedExperiment' object. Assay used as data matrix with features in rows and samples in columns. See SummarizedExperiment-class
ncomp	number of components. Default value is 10
filter.thr	filter rows in input matrix with max value > 'filter.thr'. Default value is NULL
reduced	If TRUE returns reduced result (no X, see 'return')
fun	the functional form of the G function used in the approximation to neg-entropy in fastICA. Default value is "logcosh"
alg.typ	parameter for fastICA(). if alg.typ == "deflation" the components are extracted one at a time. if alg.typ == "parallel" the components are extracted simultaneously. Default value is "deflation"

Value

a list with

X	input 'SummarizedExperiment' object
nsamples, nfeatures	dimension of X assay
S, M	consensus metagene and weight matrix
ncomp	number of components

Author(s)

Petr V. Nazarov

See Also

fastICA

Examples

```
data("samples_data")
res <- oneICA(samples_data)
```

---

plotICVarianceExplained

Barplot variance explained by each IC

Description

Method to plot variance explained (R-squared) by the MOFA model for each view and latent factor. As a measure of variance explained for gaussian data we adopt the coefficient of determination (R2).
For details on the computation see the help of the estimateVarianceExplained function

Usage

```
plotICVarianceExplained(
  cica,
  sort = NULL,
  las = 2,
  title = "Variance explained per IC",
  x.cex = NULL,
  ...
)
```

Arguments

cica	consICA compliant list
sort	specify the arrangement as 'asc'/'desc'. No sorting if NULL
las	orientation value for the axis labels (0 - always parallel to the axis, 1 - always horizontal, 2 - always perpendicular to the axis, 3 - always vertical)
title	character string with title of the plot
x.cex	specify the size of the tick label numbers/text with a numeric value of length 1
...	extra arguments to be passed to barplot

Value

A numeric vector compliant to 'barplot' output

Examples

```
data("samples_data")
cica <- consICA(samples_data, ncomp=15, ntry=10, show.every=0)
p <- plotICVarianceExplained(cica, sort = "asc")
```

---

samples_data *Samples of gene expression*

Description

A dataset containing the expression of 2454 genes for 472 samples from skin cutaneous melanoma (SKCM) TCGA cohort, their metadata such as age, gender, cancer type etc. and survival time-to-event data

Usage

```
data(samples_data)
```

Format

A SummarizedExperiment object:

assay expression matrix with genes by rows and samples by columns

colData data frame with sample metadata (clinical variables)

`saveReport` *Save PDF report with analysis of each independent component*

Description

Save PDF report with description of each independent component (IC) consists of most affected genes, significant Go terms, survival model for the component, ANOVA analysis for samples characteristics and stability

Usage

```
saveReport(
  cica,
  Genes = NULL,
  Var = NULL,
  surv = NULL,
  genenames = NULL,
  file = sprintf("report_ICA_%d.pdf", ncol(IC$S)),
  main = "Component # %d (stability = %.3f)",
  show.components = seq.int(1, ncol(cica$S))
)
```

Arguments

`cica`	list compliant to ‘consICA()‘ result. May include GO list with enrichment analysis appended with ‘getGO()‘ function
`Genes`	features list compilant to ‘getFeatures‘ output (list of dataframes ‘pos‘ for positive and ‘neg‘ for negative affecting features with names of features false discovery rates columns).If NULL will generated automatically
`Var`	matrix with samples metadata
`surv`	dataframe with time and event values for each sample
`genenames`	alternative gene names for printing in the report
`file`	report filename, ends with ".pdf"
`main`	title for each list discribes the component
`show.components`	which compont will be shown

Value

TRUE when successfully generate report

Author(s)

Petr V. Nazarov

Examples

```
data("samples_data")
cica <- consICA(samples_data, ncomp=40, ntry=10, show.every=0)
if(FALSE){
cica <- getGO(cica, db = "BP")
}
saveReport(cica, Var=samples_data$Var, surv = samples_data$Sur)
```

---

setOrientation *Set orientation for independent components*

Description

Set orientation for independent components as positive in most enriched direction. Use first element of ‘GOs‘ for direction establishment.

Usage

```
setOrientation(cica, verbose = FALSE)
```

Arguments

cica	list compliant to ‘consICA()‘ result. Must contain GO, see ‘getGO()‘
verbose	logic TRUE or FALSE. Use TRUE for print process steps. Default is FALSE

Value

cica object after rotation, with rotated ‘S‘, ‘M‘ and added ‘compsign‘ which is vector defined rotation: ‘S_rot = S * compsign, M_rot = M * compsign, GO_rot = GO * compsign‘

Note

Implemented inside ‘getGO()‘ in version >= 1.1.1.

Author(s)

Petr V. Nazarov

Examples

```
## Not run:
data("samples_data")
# Get deconvolution of X matrix
#cica <-  consICA(samples_data, ncomp=10, ntry=1, show.every=0)
cica <- consICA(samples_data, ncomp=2, ntry=1, show.every=0) # timesaving
example
GOs <- getGO(cica, db = "BP")
# Get already rotated S matrix and Gene Ontologies
cica <- getGO(cica, db = "BP")

# Get Gene Ontologies without rotation (actually, you don't need to do this)
# This may used for GO generated with version < 1.1.1. Add GO to cica list.
cica <- getGO(cica, db = "BP", rotate = FALSE)
# Rotate components
cica <- setOrientation(cica, verbose = T)
# Which components was rotated
which(cica$compsign == -1)

## End(Not run)
```

`set_bpparam` *Set up for the parallel computing for biocParallel Adapt from 'FEAST' This function sets up the environment for parallel computing.*

Description

Set up for the parallel computing for biocParallel Adapt from 'FEAST' This function sets up the environment for parallel computing.

Usage

```
set_bpparam(ncores = 0, BPPARAM = NULL)
```

Arguments

`ncores`	number of processors
`BPPARAM`	bpparameter from bpparam

Value

BAPPARAM settings

sortDataFrame *Sort dataframe*

Description

Sort dataframe, adapted from http://snippets.dzone.com/user/r-fanatic

Usage

```
sortDataFrame(x,key, ...)
```

Arguments

x	a data.frame
key	sort by this column
...	other parameters for ‘order‘ function (e. g. ‘decreasing‘)

Value

sorted dataframe

Examples

```
df <- data.frame("features" = c("f1", "f2", "f3"), fdr = c(0.02, 0.002, 1))
sortDataFrame(df, "fdr")
```

sortFeatures *Sort Genes of consICA object*

Description

Sort Genes for independent components

Usage

```
sortFeatures(Genes)
```

Arguments

Genes	list compilant to ‘getFeatures‘output

Value

sorted list

Examples

```
#features <- list("ic1" = list(
#              "pos" = data.frame("features" = c("f1", "f2", "f3"),
#                                 "fdr" = c(0.0043, 0.4, 0.04)),
#              "neg" = data.frame("features" = c("f1", "f2", "f3"),
#                                 "fdr" = c(0, 0.1, 0.9))))
#sortFeatures(features)
```

`survivalAnalysis` *Survival analysis based on significant IC*

Description

Cox regression (based on R package 'survival') on the weights of independent components with significant contribution in individual risk model. For more see Nazarov et al. 2019 In addition the function plot Kaplan-Meier diagram.

Usage

```
survivalAnalysis(cica, surv = NULL, time = NULL, event = NULL, fdr = 0.05)
```

Arguments

`cica`	list compliant to 'consICA()' result
`surv`	dataframe with time and event values for each sample. Use this parameter or 'time' and 'event'
`time`	survival time value for each sample
`event`	survival event factor for each sample (TRUE or FALSE)
`fdr`	false discovery rate threshold for significant components involved in final model. Default value is 0.05

Value

a list with

`cox.model`	an object of class 'coxph' representing the fit. See 'coxph.object' for details
`hazard.score`	hazard score for significant components (fdr < 'fdr' in individual cox model)

Examples

```
data("samples_data")
# Get deconvolution of X matrix
cica <-  consICA(samples_data, ncomp=10, ntry=1, show.every=0)
surv <- survivalAnalysis(cica,
  surv = SummarizedExperiment::colData(samples_data)[,c("time", "event")])
```

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