

# Package ‘scTensor’

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**Description** The algorithm is based on the non-negative tucker decomposition (NTD2) of nnTensor.

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scTensor-package	<i>Detection of cell-cell interaction from single-cell RNA-seq dataset by tensor decomposition</i>
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## Description

The algorithm is based on the non-negative tucker decomposition (NTD2) of nnTensor.

## Details

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## Author(s)

NA

Maintainer: NA

## See Also

[GermMale](#), [labelGermMale](#), [tsneGermMale](#), [cellCellSetting](#), [cellCellDecomp](#), [cellCellReport](#)

## Examples

```
ls("package:scTensor")
```

---

CCSPARAMS-class      *Class "CCSPARAMS"*

---

### Description

The parameter object to be specified against cellCellSimulate function.

### Objects from the Class

Objects can be created by calls of the form `new("CCSPARAMS", ...)`.

### Slots

**nGene:** The number of genes.

**nCell:** The number of cells.

**cciInfo:** The parameter to describe the CCI.

**lambda:** The parameter for dropout simulation.

**seed:** The seed for using random numbers.

### Methods

**newCCSPARAMS** Generator of CCSPARAMS object.

**getParam** Getter function of the slot in CCSPARAMS object.

**setParam<-** Setter function of the slot in CCSPARAMS object.

### See Also

[newCCSPARAMS](#), [getParam](#), [setParam<-](#)

---

cellCellDecomp      *Performing scTensor*

---

### Description

All parameters is saved to metadata slot of SingleCellExperiment object.

### Usage

```
cellCellDecomp(sce, algorithm=c("ntd2", "ntd", "nmf", "pearson",
  "spearman", "distance", "pearson.lr", "spearman.lr", "distance.lr",
  "pcomb", "label.permutation", "cabello.aguilar", "halpern"), ranks=c(3,3), rank=3, thr1=log2(5)
  centering=TRUE, mergeas=c("mean", "sum"), outerfunc=c("*", "+"),
  comb=c("random", "all"), num.sampling=100, num.perm=1000, assayNames = "counts", decomp=TRUE)
```

**Arguments**

sce	The object generated by instantiation of SingleCellExperiment-class.
algorithm	Algorithm for constructing cell-cell similarity matrix. "ntd2", "ntd", "nmf", "pearson", "spearman", "distance", "pearson.lr", "spearman.lr", "distance.lr", "pcomb" or "label.permutation" can be specified (Default: ntd2).
ranks	The size of the core tensor decomposed by NTD. Each element means (Number of Ligand-Cell Pattern, Number of Receptor-Cell Pattern, Number of LR-pairs Pattern) (Default: c(3,3)).
rank	The number of low dimension of NMF (Default: 3).
thr1	The threshold used by pcomb (Default: log2(5)).
thr2	The threshold used by pcomb (Default: 25).
verbose	The verbose parameter for nnTensor::NTD (Default: FALSE).
centering	When the value is TRUE, input matrix is summarized as celltype-level vectors (Default: TRUE).
mergeas	When the centering is TRUE, "sum" (celltype-level sum vector) or "mean" (celltype-level average vector) is calculated (Default: "sum").
outerfunc	When the centering is TRUE, "+" (Kronecker sum) or "*" (Kronecker product) is calculated (Default: "+").
comb	When the centering is FALSE, "random" (random cell-cell pairing) or "all" (all possible cell-cell pairing) is calculated (Default: "random").
num.sampling	The number of random sampling used (Default: 100).
num.perm	The number of the permutation in label permutation test (Default: 1000).
assayNames	The unit of gene expression for using scTensor (e.g. normcounts, cpm...etc) (Default: "counts").
decomp	When the value is TRUE, cell-cell interaction tensor is decomposed (Default: TRUE).

**Value**

The result is saved to metadata slot of SingleCellExperiment object.

**Author(s)**

Koki Tsuyuzaki

**See Also**

[SingleCellExperiment](#).

**Examples**

```
showMethods("cellCellDecomp")
```

---

cellCellRanks	<i>Rank estimation of the CCI-tensor</i>
---------------	--

---

**Description**

SVD is performed in each mode.

**Usage**

```
cellCellRanks(sce, centering=TRUE,
  mergeas=c("mean", "sum"), outerfunc=c("*", "+"), comb=c("random", "all"),
  num.sampling=100, num.perm=1000, assayNames = "counts", verbose=FALSE,
  num.iter1=5, num.iter2=5, num.iter3=NULL)
```

**Arguments**

sce	A object generated by instantiztion of SingleCellExperiment-class.
centering	When the value is TRUE, input matrix is summarized as celltype-level vectors (Default: TRUE).
mergeas	When the centering is TRUE, "mean" (celltype-level mean vector) or "sum" (celltype-level sum vector) is calculated (Default: "mean").
outerfunc	When the centering is TRUE, "*" (Kronecker product) or "+" (Kronecker sum) or is calculated (Default: "+").
comb	When the centering is FALSE, "random" (random cell-cell pairing) or "all" (all possible cell-cell pairing) is calced (Default: "random").
num.sampling	The number of random sampling used (Default: 100).
num.perm	The number of the permutation in label permutation test (Default: 1000).
assayNames	The unit of gene expression for using scTensor (e.g. normcounts, cpm...etc) (Default: "counts").
verbose	The verbose parameter for nnTensor::NTD (Default: FALSE).
num.iter1	The number of iteration to estimate the rank of mode-1 matricised data tensor (Default: 5).
num.iter2	The number of iteration to estimate the rank of mode-2 matricised data tensor (Default: 5).
num.iter3	The number of iteration to estimate the rank of mode-3 matricised data tensor (Default: NULL).

**Value**

RSS: A list with three elements, in which each element means the average reconstructed error in each rank. selected: A vector with three elements, in which each element means the estimated ranks in mode-1, 2 and 3 matricization.

**Author(s)**

Koki Tsuyuzaki

**See Also**

[SingleCellExperiment](#).

**Examples**

```
showMethods("cellCellRanks")
```

---

cellCellReport	<i>HTML report of the result of scTensor</i>
----------------	--

---

**Description**

The result is saved as HTML report which contains with multiple files.

**Usage**

```
cellCellReport(sce, reducedDimNames,
  out.dir=tempdir(), html.open=FALSE,
  title="The result of scTensor",
  author="The person who runs this script", assayNames = "counts", thr=100,
  top="full", p=0.05, upper=20,
  goenrich=TRUE, meshenrich=TRUE, reactomeenrich=TRUE,
  doenrich=TRUE, ncgenrich=TRUE, dgngenrich=TRUE, nbins=40)
```

**Arguments**

sce	A object generated by instantiation of SingleCellExperiment-class.
reducedDimNames	The name of two-dimensional data saved in reducedDimNames slot of SingleCellExperiment object.
out.dir	The output directory for saving HTML report (out.dir: tempdir()).
html.open	Whether the result of HTML report is opened when the calculation is finished (Default: FALSE).
title	The title of HTML report (Default: "The result of scTensor").
author	The author of HTML report (Default: "The person who runs this script").
assayNames	The unit of gene expression for using scTensor (e.g. normcounts, cpm...etc) (Default: "counts").
thr	The threshold for selection of top percentage of core tensor elements (Default: 100 (1 to 100)).
top	top genes in each (*,*,*)-pattern which are selected and summarized in the report (Default: "full")
p	The threshold of p-value of the enrichment analysis (Default: 1E-2)
upper	The maximum number of HTML reports generates (Default: 20)
goenrich	Whether GO-Enrichment analysis is performed (Default: TRUE)
meshenrich	Whether MeSH-Enrichment analysis is performed (Default: TRUE)
reactomeenrich	Whether Reactome-Enrichment analysis is performed (Default: TRUE)
doenrich	Whether DO-Enrichment analysis is performed (Default: TRUE)
ncgenrich	Whether NCG-Enrichment analysis is performed (Default: TRUE)
dgngenrich	Whether DGN-Enrichment analysis is performed (Default: TRUE)
nbins	The number of bins used for the two dimensional plot of schex (Default: 40)

**Value**

The result is saved as HTML report which contains with multiple files.

**Author(s)**

Koki Tsuyuzaki

**See Also**

[SingleCellExperiment](#).

**Examples**

```
if(interactive()){
# Package Loading
library("SingleCellExperiment")
if(!require(LRBase.Hsa.eg.db)){
  BiocManager::install("LRBase.Hsa.eg.db")
  library(LRBase.Hsa.eg.db)
}

# Data Loading
data(GermMale)
data(labelGermMale)
data(tsneGermMale)

# SingleCellExperiment Object
sce <- SingleCellExperiment(assays=list(counts = GermMale))
reducedDims(sce) <- SimpleList(TSNE=tsneGermMale$Y)

# User's Original Normalization Function
CPMED <- function(input){
  libsize <- colSums(input)
  median(libsize) * t(t(input) / libsize)
}
# Normalization
normcounts(sce) <- log10(CPMED(counts(sce)) + 1)

# Registration of required information into metadata(sce)
cellCellSetting(sce, LRBase.Hsa.eg.db, names(labelGermMale))

# Rank Estimation
rks <- cellCellRanks(sce, assayNames="normcounts")

# CCI Tensor Decomposition
set.seed(1234)
cellCellDecomp(sce, ranks=rks$selected, assayNames="normcounts")

# HTML Report
options(device.ask.default = FALSE)
cellCellReport(sce, reducedDimNames="TSNE",
  out.dir=tempdir(), html.open=FALSE,
  title="The result of scTensor",
  author="The person who runs this script",
  assayNames="counts", thr=100,
  top="full", p=0.05, upper=20,
```

```

        goenrich=TRUE, meshenrich=TRUE, reactomeenrich=TRUE,
        doenrich=TRUE, ncgenrich=TRUE, dgenrich=TRUE, nbins=40)
    }else{
        showMethods("cellCellReport")
    }
}

```

---

cellCellSetting

*Parameter setting for scTensor*


---

### Description

All parameters is saved to metadata slot of SingleCellExperiment object.

### Usage

```
cellCellSetting(sce, lrbase, label, lr.evidence="all", color=NULL)
```

### Arguments

sce	A object generated by instantiztion of SingleCellExperiment-class.
lrbase	Ligand-Receptor database (LRBase.XXX.eg.db-type package).
label	Cellular label information for distingusishing which cells belong to common celltypes.
lr.evidence	The evidence code for L-R pair list (Default: "all"). When you specify "known", DLRP, IUPHAR, HPMR, CELLPHONEDB, SINGLECELLSIGNALR are searched, and other databases are searched, when you specify "putative". You can also specify multiple databases at once (e.g. c("SWISSPROT_STRING", "TREMBL_STRING")). cf. <a href="https://github.com/rikenbit/lrbase-workflow">https://github.com/rikenbit/lrbase-workflow</a>
color	Color scheme for adding color against the cells (Default: NULL). If the value is not specified, automatically the color vector is generated.

### Value

The result is saved to metadata slot of SingleCellExperiment object.

### Author(s)

Koki Tsuyuzaki

### See Also

[SingleCellExperiment](#).

### Examples

```
showMethods("cellCellSetting")
```



---

cellCellSimulate      *Parameter Simulate for scTensor*

---

### Description

All parameters is saved to metadata slot of SingleCellExperiment object.

### Usage

```
cellCellSimulate(params = newCCSParams(), verbose = TRUE)
```

### Arguments

params	A parameter object generated by newCCSParams().
verbose	Whether the message is outputted or not (Default: TRUE).

### Value

A list object containing simcount, LR, and celltype. simcount is the synthetic count matrix, LR is the synthetic ligand-receptor pair list, and celltype is the vector to specify the celltype of the each column of simcount.

### Author(s)

Koki Tsuyuzaki

### Examples

```
showMethods("cellCellSimulate")
```

---

convertToNCBIGeneID      *ID conversion function to create the input matrix for scTensor*

---

### Description

Duplicated row names or NA row names are removed from input matrix, and the matrix with the row names of NCBI Gene ID is generated.

### Usage

```
convertToNCBIGeneID(input, rowID, LefttoRight)
```

### Arguments

input	Input matrix (or data.frame).
rowID	Gene identifier in each row of the input matrix. The length of rowID must be same as the number of tht input matrix.
LefttoRight	Corresponding table with left column (Gene identifier <same type of row ID>) and right column (NCBI Gene ID).

**Value**

A matrix object with with the row names of NCBI Gene ID.

**Author(s)**

Koki Tsuyuzaki

**Examples**

```
input <- matrix(1:20, nrow=4, ncol=5)
rowID <- c("A", NA, "B", "B")
LefttoRight <- rbind(
  c("A", "1"),
  c("B", "2"),
  c("B", "4"),
  c("D", NA)
)
(input <- convertToNCBIGeneID(input, rowID, LefttoRight))
```

---

GermMale

*The matrix which is used as test data of scTensor.*

---

**Description**

A matrix with 242 rows (genes) \* 852 columns (cells).

**Usage**

```
data(GermMale)
```

**Details**

The data matrix is downloaded from GEO Series GSE86146 (<https://www.ncbi.nlm.nih.gov/geo/download/?acc=GSE86146>). Only male data is extracted and then the gene symbol is converted to NCBI Gene ID by Homo.sapiens package.

For saving the package size, the number of genes are strictly reduced by the standard of highly variable genes with threshold of p-value is 1E-300.

**References**

Li L. and Dong J. and Yan L. and Yong J. et al. (2017) Single-Cell RNA-Seq Analysis Maps Development of Human Germline Cells and Gonadal Niche Interactions. *Cell Stem Cell*, **20(6)**: 858-873

**See Also**

[labelGermMale](#), [tsneGermMale](#).

**Examples**

```
data(GermMale)
```

---

getParam	<i>Get a parameter</i>
----------	------------------------

---

**Description**

Accessor function for getting parameter values.

**Usage**

```
getParam(object, name)
```

```
## S4 method for signature 'CCSParams'  
getParam(object, name)
```

**Arguments**

object	object to get parameter from.
name	name of the parameter to get.

**Value**

The extracted parameter value

**Examples**

```
params <- newCCSParams()  
  
getParam(params, "nGene")  
getParam(params, "nCell")  
getParam(params, "cciInfo")  
getParam(params, "lambda")  
getParam(params, "seed")
```

---

labelGermMale	<i>The vector contains the celltype information and color scheme of GermMale</i>
---------------	--

---

**Description**

A vector with 852 length (cells).

**Usage**

```
data(labelGermMale)
```

**Details**

The Cluster label is downloaded from original paper page of Cell Stem Cell (<https://www.sciencedirect.com/science/article>)

**References**

Li L. and Dong J. and Yan L. and Yong J. et al. (2017) Single-Cell RNA-Seq Analysis Maps Development of Human Germline Cells and Gonadal Niche Interactions. *Cell Stem Cell*, **20(6)**: 858-873

**See Also**

[GermMale](#), [tsneGermMale](#).

**Examples**

```
data(labelGermMale)
```

---

m	<i>The gene-wise mean vector of Quartz-Seq data.</i>
---	--

---

**Description**

This data is internally used in cellCellSimulate function.

**Usage**

```
data(m)
```

**Examples**

```
data(m)
```

---

newCCSParams	<i>New Params</i>
--------------	-------------------

---

**Description**

Create a new CCSParams object.

**Usage**

```
newCCSParams()
```

**Arguments**

Nothing.

**Value**

New Params object.

**Examples**

```
params <- newCCSParams()
```

---

setParam	<i>Set a parameter</i>
----------	------------------------

---

## Description

Function for setting parameter values.

## Usage

```
setParam(object, name) <- value  
## S4 method for signature 'CCSParams'  
setParam(object, name, value)
```

## Arguments

object	object to set parameter in.
name	name of the parameter to set.
value	value to set the parameter to.

## Value

Object with new parameter value.

## Examples

```
params <- newCCSParams()  
  
setParam(params, "nGene") <- 20000  
setParam(params, "nCell") <- c(12, 43, 323)  
setParam(params, "cciInfo") <- list(nPair=2000,  
  CCI1=list(  
    LPattern=c(1,0,0),  
    RPattern=c(0,1,1),  
    nGene=100,  
    fc="E10"),  
  CCI2=list(  
    LPattern=c(0,0,1),  
    RPattern=c(1,1,1),  
    nGene=200,  
    fc="E10"),  
  CCI3=list(  
    LPattern=c(1,1,1),  
    RPattern=c(1,0,1),  
    nGene=300,  
    fc="E10")  
)  
  
setParam(params, "lambda") <- 0.1  
setParam(params, "seed") <- 111
```

---

`tsneGermMale`*The result of Rtsne against GermMale*

---

**Description**

A List contains some parameters and the result of Rtsne function.

**Usage**

```
data(tsneGermMale)
```

**Details**

Rtsne is performed as follows.

```
library(Rtsne) set.seed(123) tsneGermMale <- Rtsne(dist(t(GermMale)), is_distance=TRUE, perplexity=40)
```

**References**

Li L. and Dong J. and Yan L. and Yong J. et al. (2017) Single-Cell RNA-Seq Analysis Maps Development of Human Germline Cells and Gonadal Niche Interactions. *Cell Stem Cell*, **20(6)**: 858-873

**See Also**

[labelGermMale](#), [GermMale](#).

**Examples**

```
data(tsneGermMale)
```

---

`v`*The gene-wise variance vector of Quartz-Seq data.*

---

**Description**

This data is internally used in cellCellSimulate function.

**Usage**

```
data(v)
```

**Examples**

```
data(v)
```

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