Package: celda (via r-universe)

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Title CEllular Latent Dirichlet Allocation

Version 1.28.0

Description Celda is a suite of Bayesian hierarchical models for clustering single-cell RNA-sequencing (scRNA-seq) data. It is able to perform ``bi-clustering'' and simultaneously cluster genes into gene modules and cells into cell subpopulations. It also contains DecontX, a novel Bayesian method to computationally estimate and remove RNA contamination in individual cells without empty droplet information. A variety of scRNA-seq data visualization functions is also included.

Depends R (>= 4.0), SingleCellExperiment, Matrix

VignetteBuilder knitr

Imports plyr, foreach, ggplot2, RColorBrewer, grid, scales, gtable, grDevices, graphics, matrixStats, doParallel, digest, methods, reshape2, S4Vectors, data.table, Rcpp, RcppEigen, uwot, enrichR, SummarizedExperiment, MCMCprecision, ggrepel, Rtsne, withr, scater (>= 1.14.4), scran, dbscan, DelayedArray, stringr, ComplexHeatmap, gridExtra, circlize, dendextend, ggdendro, pROC

Suggests testthat, knitr, roxygen2, rmarkdown, biomaRt, covr, BiocManager, BiocStyle, TENxPBMCData, singleCellTK, M3DExampleData

LinkingTo Rcpp, RcppEigen

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Contents

appendCeldaList . . . 4
availableModels . . . 4
bestLogLikelihood . . . 5
celda . . . 5
celda_C . . . 6
celda_CG . . . 9
celda_G . . . 13
celdaCGGridSearchRes . . . 16
celdaCGMod . . . 16
celdaCGSim . . . 16
celdaClusters . . . 17
celdaCMod . . . 18
celdaCSim . . . 18
celdaGMod . . . 19
celdaGridSearch . . . 19
celdaGSim . . . 22
celdaHeatmap . . . 22
celdaModel . . . 23
celdaModules . . . 24
celdaPerplexity . . . 25
celdaPerplexity,celdaList-method . . . 25
celdaProbabilityMap . . . 26
celdatosce . . . 28
celdaTsne . . . 29
celdaUmap . . . 31
clusterProbability . . . 34
compareCountMatrix . . . 35
contaminationSim . . . 36
countChecksum . . . 36
countChecksum,celdaList-method . . . 37
decontX . . . 37
decontXcounts . . . 41
distinctColors . . . 41
eigenMatMultInt . . . 42
eigenMatMultNumeric . . . 43
factorizeMatrix . . . 43
fastNormProp . . . 45

fastNormPropLog . . . 45
fastNormPropSqrt . . . 46
featureModuleLookup . . . 46
featureModuleTable . . . 48
findMarkersTree . . . 49
geneSetEnrich . . . 51
getDecisions . . . 53
logLikelihood . . . 53
logLikelihoodHistory . . . 54
matrixNames . . . 55
moduleHeatmap . . . 56
nonzero . . . 59
normalizeCounts . . . 60
params . . . 61
perplexity . . . 62
plotCeldaViolin . . . 63
plotDecontXContamination . . . 65
plotDecontXMarkerExpression . . . 66
plotDecontXMarkerPercentage . . . 67
plotDendro . . . 69
plotDimReduceCluster . . . 70
plotDimReduceFeature . . . 72
plotDimReduceGrid . . . 76
plotDimReduceModule . . . 79
plotGridSearchPerplexity . . . 81
plotHeatmap . . . 82
plotMarkerHeatmap . . . 85
plotRPC . . . 86
recodeClusterY . . . 87
recodeClusterZ . . . 88
recursiveSplitCell . . . 89
recursiveSplitModule . . . 92
reorderCelda . . . 96
reportceldaCG . . . 97
resamplePerplexity . . . 100
resList . . . 102
retrieveFeatureIndex . . . 102
runParams . . . 104
sampleCells . . . 104
sampleLabel . . . 105
sceCeldaC . . . 106
sceCeldaCG . . . 106
sceCeldaCGGridSearch . . . 107
sceCeldaG . . . 108
selectBestModel . . . 108
selectFeatures . . . 109
semiPheatmap . . . 111
simulateCells . . . 116

simulateContamination 117
splitModule 118
subsetCeldaList 120
topRank 121

Index **122**

`appendCeldaList` *Append two celdaList objects*

Description

Returns a single celdaList representing the combination of two provided celdaList objects.

Usage

```
appendCeldaList(list1, list2)
```

Arguments

`list1`	A celda_list object
`list2`	A celda_list object to be joined with list_1

Value

A celdaList object. This object contains all resList entries and runParam records from both lists.

Examples

```
data(celdaCGGridSearchRes)
appendedList <- appendCeldaList(
  celdaCGGridSearchRes,
  celdaCGGridSearchRes
)
```

`availableModels` *available models*

Description

available models

Usage

```
availableModels
```

Format

An object of class `character` of length 3.

bestLogLikelihood *Get the log-likelihood*

Description

Retrieves the final log-likelihood from all iterations of Gibbs sampling used to generate a celdaModel.

Usage

```
bestLogLikelihood(x, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
bestLogLikelihood(x, altExpName = "featureSubset")

## S4 method for signature 'celdaModel'
bestLogLikelihood(x)
```

Arguments

x	A SingleCellExperiment object returned by celda_C, celda_G, or celda_CG, or a celda model object.
altExpName	The name for the altExp slot to use. Default "featureSubset".

Value

Numeric. The log-likelihood at the final step of Gibbs sampling used to generate the model.

Examples

```
data(sceCeldaCG)
bestLogLikelihood(sceCeldaCG)
data(celdaCGMod)
bestLogLikelihood(celdaCGMod)
```

celda *Celda models*

Description

List of available Celda models with correpsonding descriptions.

Usage

```
celda()
```

Value

None

Examples

```
celda()
```

`celda_C` *Cell clustering with Celda*

Description

Clusters the columns of a count matrix containing single-cell data into K subpopulations. The `useAssay` assay slot in `altExpName` altExp slot will be used if it exists. Otherwise, the `useAssay` assay slot in `x` will be used if `x` is a SingleCellExperiment object.

Usage

```
celda_C(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  K,
  alpha = 1,
  beta = 1,
  algorithm = c("EM", "Gibbs"),
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  zInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  zInit = NULL,
  logfile = NULL,
  verbose = TRUE
)

## S4 method for signature 'SingleCellExperiment'
celda_C(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  K,
```

```
  alpha = 1,
  beta = 1,
  algorithm = c("EM", "Gibbs"),
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  zInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  zInit = NULL,
  logfile = NULL,
  verbose = TRUE
)

## S4 method for signature 'ANY'
celda_C(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  K,
  alpha = 1,
  beta = 1,
  algorithm = c("EM", "Gibbs"),
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  zInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  zInit = NULL,
  logfile = NULL,
  verbose = TRUE
)
```

Arguments

x	A SingleCellExperiment with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells. Alternatively, any matrix-like object that can be coerced to a sparse matrix of class "dgCMatrix" can be directly used as input. The matrix will automatically be converted to a SingleCellExperiment object.
useAssay	A string specifying the name of the assay slot to use. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".

sampleLabel	Vector or factor. Denotes the sample label for each cell (column) in the count matrix.
K	Integer. Number of cell populations.
alpha	Numeric. Concentration parameter for Theta. Adds a pseudocount to each cell population in each sample. Default 1.
beta	Numeric. Concentration parameter for Phi. Adds a pseudocount to each feature in each cell population. Default 1.
algorithm	String. Algorithm to use for clustering cell subpopulations. One of 'EM' or 'Gibbs'. The EM algorithm is faster, especially for larger numbers of cells. However, more chains may be required to ensure a good solution is found. If 'EM' is selected, then 'stopIter' will be automatically set to 1. Default 'EM'.
stopIter	Integer. Number of iterations without improvement in the log likelihood to stop inference. Default 10.
maxIter	Integer. Maximum number of iterations of Gibbs sampling or EM to perform. Default 200.
splitOnIter	Integer. On every 'splitOnIter' iteration, a heuristic will be applied to determine if a cell population should be reassigned and another cell population should be split into two clusters. To disable splitting, set to -1. Default 10.
splitOnLast	Integer. After 'stopIter' iterations have been performed without improvement, a heuristic will be applied to determine if a cell population should be reassigned and another cell population should be split into two clusters. If a split occurs, then 'stopIter' will be reset. Default TRUE.
seed	Integer. Passed to with_seed. For reproducibility, a default value of 12345 is used. If NULL, no calls to with_seed are made.
nchains	Integer. Number of random cluster initializations. Default 3.
zInitialize	Character. One of 'random', 'split', or 'predefined'. With 'random', cells are randomly assigned to a populations. With 'split', cells will be split into sqrt(K) populations and then each population will be subsequently split into another sqrt(K) populations. With 'predefined', values in 'zInit' will be used to initialize 'z'. Default 'split'.
countChecksum	Character. An MD5 checksum for the 'counts' matrix. Default NULL.
zInit	Integer vector. Sets initial starting values of z. 'zInit' is only used when 'zInitialize = 'predfined''. Default NULL.
logfile	Character. Messages will be redirected to a file named 'logfile'. If NULL, messages will be printed to stdout. Default NULL.
verbose	Logical. Whether to print log messages. Default TRUE.

Value

A SingleCellExperiment object. Function parameter settings are stored in the metadata "celda_parameters" slot. Columns celda_sample_label and celda_cell_cluster in colData contain sample labels and celda cell population clusters.

See Also

celda_G for feature clustering and celda_CG for simultaneous clustering of features and cells. celdaGridSearch can be used to run multiple values of K and multiple chains in parallel.

Examples

```
data(celdaCSim)
sce <- celda_C(celdaCSim$counts,
    K = celdaCSim$K,
    sampleLabel = celdaCSim$sampleLabel,
    nchains = 1)
```

---

celda_CG *Cell and feature clustering with Celda*

Description

Clusters the rows and columns of a count matrix containing single-cell data into L modules and K subpopulations, respectively. The `useAssay` assay slot in `altExpName` altExp slot will be used if it exists. Otherwise, the `useAssay` assay slot in `x` will be used if `x` is a SingleCellExperiment object.

Usage

```
celda_CG(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  K,
  L,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  algorithm = c("EM", "Gibbs"),
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  zInitialize = c("split", "random", "predefined"),
  yInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  zInit = NULL,
  yInit = NULL,
  logfile = NULL,
```

```
  verbose = TRUE
)

## S4 method for signature 'SingleCellExperiment'
celda_CG(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  K,
  L,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  algorithm = c("EM", "Gibbs"),
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  zInitialize = c("split", "random", "predefined"),
  yInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  zInit = NULL,
  yInit = NULL,
  logfile = NULL,
  verbose = TRUE
)

## S4 method for signature 'ANY'
celda_CG(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  K,
  L,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  algorithm = c("EM", "Gibbs"),
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
```

```
  seed = 12345,
  nchains = 3,
  zInitialize = c("split", "random", "predefined"),
  yInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  zInit = NULL,
  yInit = NULL,
  logfile = NULL,
  verbose = TRUE
)
```

Arguments

x	A SingleCellExperiment with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells. Alternatively, any matrix-like object that can be coerced to a sparse matrix of class "dgCMatrix" can be directly used as input. The matrix will automatically be converted to a SingleCellExperiment object.
useAssay	A string specifying the name of the assay slot to use. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
sampleLabel	Vector or factor. Denotes the sample label for each cell (column) in the count matrix.
K	Integer. Number of cell populations.
L	Integer. Number of feature modules.
alpha	Numeric. Concentration parameter for Theta. Adds a pseudocount to each cell population in each sample. Default 1.
beta	Numeric. Concentration parameter for Phi. Adds a pseudocount to each feature module in each cell population. Default 1.
delta	Numeric. Concentration parameter for Psi. Adds a pseudocount to each feature in each module. Default 1.
gamma	Numeric. Concentration parameter for Eta. Adds a pseudocount to the number of features in each module. Default 1.
algorithm	String. Algorithm to use for clustering cell subpopulations. One of 'EM' or 'Gibbs'. The EM algorithm for cell clustering is faster, especially for larger numbers of cells. However, more chains may be required to ensure a good solution is found. Default 'EM'.
stopIter	Integer. Number of iterations without improvement in the log likelihood to stop inference. Default 10.
maxIter	Integer. Maximum number of iterations of Gibbs sampling to perform. Default 200.
splitOnIter	Integer. On every splitOnIter iteration, a heuristic will be applied to determine if a cell population or feature module should be reassigned and another cell population or feature module should be split into two clusters. To disable splitting, set to -1. Default 10.

splitOnLast	Integer. After stopIter iterations have been performed without improvement, a heuristic will be applied to determine if a cell population or feature module should be reassigned and another cell population or feature module should be split into two clusters. If a split occurs, then 'stopIter' will be reset. Default TRUE.
seed	Integer. Passed to with_seed. For reproducibility, a default value of 12345 is used. If NULL, no calls to with_seed are made.
nchains	Integer. Number of random cluster initializations. Default 3.
zInitialize	Chararacter. One of 'random', 'split', or 'predefined'. With 'random', cells are randomly assigned to a populations. With 'split', cells will be split into sqrt(K) populations and then each population will be subsequently split into another sqrt(K) populations. With 'predefined', values in zInit will be used to initialize z. Default 'split'.
yInitialize	Character. One of 'random', 'split', or 'predefined'. With 'random', features are randomly assigned to a modules. With 'split', features will be split into sqrt(L) modules and then each module will be subsequently split into another sqrt(L) modules. With 'predefined', values in yInit will be used to initialize y. Default 'split'.
countChecksum	Character. An MD5 checksum for the counts matrix. Default NULL.
zInit	Integer vector. Sets initial starting values of z. 'zInit' is only used when 'zInitialize = 'predfined''. Default NULL.
yInit	Integer vector. Sets initial starting values of y. 'yInit' is only be used when 'yInitialize = "predefined"'. Default NULL.
logfile	Character. Messages will be redirected to a file named 'logfile'. If NULL, messages will be printed to stdout. Default NULL.
verbose	Logical. Whether to print log messages. Default TRUE.

Value

A SingleCellExperiment object. Function parameter settings are stored in metadata "celda_parameters" in altExp slot. In altExp slot, columns celda_sample_label and celda_cell_cluster in colData contain sample labels and celda cell population clusters. Column celda_feature_module in rowData contains feature modules.

See Also

celda_G for feature clustering and celda_C for clustering cells. celdaGridSearch can be used to run multiple values of K/L and multiple chains in parallel.

Examples

```
data(celdaCGSim)
sce <- celda_CG(celdaCGSim$counts,
    K = celdaCGSim$K,
    L = celdaCGSim$L,
    sampleLabel = celdaCGSim$sampleLabel,
    nchains = 1)
```

celda_G *Feature clustering with Celda*

Description

Clusters the rows of a count matrix containing single-cell data into L modules. The `useAssay` assay slot in `altExpName` altExp slot will be used if it exists. Otherwise, the `useAssay` assay slot in `x` will be used if `x` is a SingleCellExperiment object.

Usage

```
celda_G(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  L,
  beta = 1,
  delta = 1,
  gamma = 1,
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  yInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  yInit = NULL,
  logfile = NULL,
  verbose = TRUE
)

## S4 method for signature 'SingleCellExperiment'
celda_G(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  L,
  beta = 1,
  delta = 1,
  gamma = 1,
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
```

```
  yInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  yInit = NULL,
  logfile = NULL,
  verbose = TRUE
)

## S4 method for signature 'ANY'
celda_G(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  L,
  beta = 1,
  delta = 1,
  gamma = 1,
  stopIter = 10,
  maxIter = 200,
  splitOnIter = 10,
  splitOnLast = TRUE,
  seed = 12345,
  nchains = 3,
  yInitialize = c("split", "random", "predefined"),
  countChecksum = NULL,
  yInit = NULL,
  logfile = NULL,
  verbose = TRUE
)
```

Arguments

x	A SingleCellExperiment with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells. Alternatively, any matrix-like object that can be coerced to a sparse matrix of class "dgCMatrix" can be directly used as input. The matrix will automatically be converted to a SingleCellExperiment object.
useAssay	A string specifying the name of the assay slot to use. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
L	Integer. Number of feature modules.
beta	Numeric. Concentration parameter for Phi. Adds a pseudocount to each feature module in each cell. Default 1.
delta	Numeric. Concentration parameter for Psi. Adds a pseudocount to each feature in each module. Default 1.
gamma	Numeric. Concentration parameter for Eta. Adds a pseudocount to the number of features in each module. Default 1.
stopIter	Integer. Number of iterations without improvement in the log likelihood to stop inference. Default 10.

maxIter	Integer. Maximum number of iterations of Gibbs sampling to perform. Default 200.
splitOnIter	Integer. On every 'splitOnIter' iteration, a heuristic will be applied to determine if a feature module should be reassigned and another feature module should be split into two clusters. To disable splitting, set to -1. Default 10.
splitOnLast	Integer. After 'stopIter' iterations have been performed without improvement, a heuristic will be applied to determine if a cell population should be reassigned and another cell population should be split into two clusters. If a split occurs, then 'stopIter' will be reset. Default TRUE.
seed	Integer. Passed to with_seed. For reproducibility, a default value of 12345 is used. If NULL, no calls to with_seed are made.
nchains	Integer. Number of random cluster initializations. Default 3.
yInitialize	Chararacter. One of 'random', 'split', or 'predefined'. With 'random', features are randomly assigned to a modules. With 'split', features will be split into sqrt(L) modules and then each module will be subsequently split into another sqrt(L) modules. With 'predefined', values in 'yInit' will be used to initialize 'y'. Default 'split'.
countChecksum	Character. An MD5 checksum for the 'counts' matrix. Default NULL.
yInit	Integer vector. Sets initial starting values of y. 'yInit' can only be used when 'yInitialize = 'predefined''. Default NULL.
logfile	Character. Messages will be redirected to a file named logfile. If NULL, messages will be printed to stdout. Default NULL.
verbose	Logical. Whether to print log messages. Default TRUE.

Value

A SingleCellExperiment object. Function parameter settings are stored in the metadata "celda_parameters" slot. Column celda_feature_module in rowData contains feature modules.

See Also

celda_C for cell clustering and celda_CG for simultaneous clustering of features and cells. celda-GridSearch can be used to run multiple values of L and multiple chains in parallel.

Examples

```
data(celdaGSim)
sce <- celda_G(celdaGSim$counts, L = celdaGSim$L, nchains = 1)
```

celdaCGGridSearchRes *celdaCGGridSearchRes*

Description

Example results of old celdaGridSearch on celdaCGSim

Usage

```
celdaCGGridSearchRes
```

Format

An object as returned from old celdaGridSearch()

celdaCGMod *celdaCGmod*

Description

celda_CG model object generated from `celdaCGSim` using old `celda_CG` function.

Usage

```
celdaCGMod
```

Format

A celda_CG object

celdaCGSim *celdaCGSim*

Description

An deprecated example of simulated count matrix from the celda_CG model.

Usage

```
celdaCGSim
```

Format

A list of counts and properties as returned from old simulateCells().

`celdaClusters` *Get or set the cell cluster labels from a celda SingleCellExperiment object or celda model object.*

Description

Return or set the cell cluster labels determined by celda_C or celda_CG models.

Usage

```
celdaClusters(x, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
celdaClusters(x, altExpName = "featureSubset")

## S4 method for signature 'celdaModel'
celdaClusters(x)

celdaClusters(x, altExpName = "featureSubset") <- value

## S4 replacement method for signature 'SingleCellExperiment'
celdaClusters(x, altExpName = "featureSubset") <- value
```

Arguments

`x`	Can be one of • A SingleCellExperiment object returned by celda_C, or celda_CG, with the matrix located in the `useAssay` assay slot. The a altExp slot with name `altExpName` will be used. Rows represent features and columns represent cells. • Celda model object.
`altExpName`	The name for the altExp slot to use. Default "featureSubset".
`value`	Character vector of cell cluster labels for replacements. Works only if `x` is a SingleCellExperiment object.

Value

One of

- Character vector if `x` is a SingleCellExperiment object. Contains cell cluster labels for each cell in x.
- List if `x` is a celda model object. Contains cell cluster labels (for celda_C and celdaCG Models) and/or feature module labels (for celda_G and celdaCG Models).

Examples

```
data(sceCeldaCG)
celdaClusters(sceCeldaCG)
data(celdaCGMod)
celdaClusters(celdaCGMod)
```

`celdaCMod` *celdaCMod*

Description

Old celda_C results generated from celdaCSim

Usage

```
celdaCMod
```

Format

A celda_C object

`celdaCSim` *celdaCSim*

Description

An old example simulated count matrix from the celda_C model.

Usage

```
celdaCSim
```

Format

A list of counts and properties as returned from old simulateCells().

celdaGMod *celdaGMod*

Description

Old celda_G results generated from celdaGsim

Usage

```
celdaGMod
```

Format

A celda_G object

celdaGridSearch *Run Celda in parallel with multiple parameters*

Description

Run Celda with different combinations of parameters and multiple chains in parallel. The variable availableModels contains the potential models that can be utilized. Different parameters to be tested should be stored in a list and passed to the argument `paramsTest`. Fixed parameters to be used in all models, such as `sampleLabel`, can be passed as a list to the argument `paramsFixed`. When `verbose = TRUE`, output from each chain will be sent to a log file but not be displayed in `stdout`.

Usage

```
celdaGridSearch(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  model,
  paramsTest,
  paramsFixed = NULL,
  maxIter = 200,
  nchains = 3,
  cores = 1,
  bestOnly = TRUE,
  seed = 12345,
  perplexity = TRUE,
  verbose = TRUE,
  logfilePrefix = "Celda"
)
```

```
## S4 method for signature 'SingleCellExperiment'
celdaGridSearch(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  model,
  paramsTest,
  paramsFixed = NULL,
  maxIter = 200,
  nchains = 3,
  cores = 1,
  bestOnly = TRUE,
  seed = 12345,
  perplexity = TRUE,
  verbose = TRUE,
  logfilePrefix = "Celda"
)

## S4 method for signature 'matrix'
celdaGridSearch(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  model,
  paramsTest,
  paramsFixed = NULL,
  maxIter = 200,
  nchains = 3,
  cores = 1,
  bestOnly = TRUE,
  seed = 12345,
  perplexity = TRUE,
  verbose = TRUE,
  logfilePrefix = "Celda"
)
```

Arguments

x	A numeric matrix of counts or a SingleCellExperiment with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.
useAssay	A string specifying the name of the assay slot to use. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
model	Celda model. Options available in availableModels.
paramsTest	List. A list denoting the combinations of parameters to run in a celda model. For example, list(K = seq(5, 10), L = seq(15, 20)) will run all combinations of K from 5 to 10 and L from 15 to 20 in model celda_CG.

paramsFixed	List. A list denoting additional parameters to use in each celda model. Default NULL.
maxIter	Integer. Maximum number of iterations of sampling to perform. Default 200.
nchains	Integer. Number of random cluster initializations. Default 3.
cores	Integer. The number of cores to use for parallel estimation of chains. Default 1.
bestOnly	Logical. Whether to return only the chain with the highest log likelihood per combination of parameters or return all chains. Default TRUE.
seed	Integer. Passed to with_seed. For reproducibility, a default value of 12345 is used. Seed values `seq(seed, (seed + nchains - 1))` will be supplied to each chain in `nchains`. If NULL, no calls to with_seed are made.
perplexity	Logical. Whether to calculate perplexity for each model. If FALSE, then perplexity can be calculated later with resamplePerplexity. Default TRUE.
verbose	Logical. Whether to print log messages during celda chain execution. Default TRUE.
logfilePrefix	Character. Prefix for log files from worker threads and main process. Default "Celda".

Value

A SingleCellExperiment object. Function parameter settings and celda model results are stored in the metadata `"celda_grid_search"` slot.

See Also

celda_G for feature clustering, celda_C for clustering of cells, and celda_CG for simultaneous clustering of features and cells. subsetCeldaList can subset the `celdaList` object. selectBestModel can get the best model for each combination of parameters.

Examples

```
## Not run:
data(celdaCGSim)
## Run various combinations of parameters with 'celdaGridSearch'
celdaCGGridSearchRes <- celdaGridSearch(celdaCGSim$counts,
  model = "celda_CG",
  paramsTest = list(K = seq(4, 6), L = seq(9, 11)),
  paramsFixed = list(sampleLabel = celdaCGSim$sampleLabel),
  bestOnly = TRUE,
  nchains = 1,
  cores = 1)

## End(Not run)
```

celdaGSim *celdaGSim*

Description

An old example simulated count matrix from the celda_G model.

Usage

```
celdaGSim
```

Format

A list of counts and properties as returned from old simulateCells()

celdaHeatmap *Plot celda Heatmap*

Description

Render a stylable heatmap of count data based on celda clustering results.

Usage

```
celdaHeatmap(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  featureIx = NULL,
  nfeatures = 25,
  ...
)

## S4 method for signature 'SingleCellExperiment'
celdaHeatmap(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  featureIx = NULL,
  nfeatures = 25,
  ...
)
```

Arguments

sce	A SingleCellExperiment object returned by celda_C, celda_G, or celda_CG.
useAssay	A string specifying which assay slot to use. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
featureIx	Integer vector. Select features for display in heatmap. If NULL, no subsetting will be performed. Default NULL. **Only used for** sce **containing celda_C model result returned by celda_C.**
nfeatures	Integer. Maximum number of features to select for each gene module. Default 25. **Only used for** sce **containing celda_CG or celda_G model results returned by celda_CG or celda_G.**
...	Additional parameters passed to plotHeatmap.

Value

list A list containing dendrogram information and the heatmap grob

See Also

'celdaTsne()' for generating 2-dimensional tSNE coordinates

Examples

```
data(sceCeldaCG)
celdaHeatmap(sceCeldaCG)
```

---

celdaModel *Get celda model from a celda SingleCellExperiment object*

Description

Return the celda model for sce returned by celda_C, celda_G or celda_CG.

Usage

```
celdaModel(sce, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
celdaModel(sce, altExpName = "featureSubset")
```

Arguments

sce	A SingleCellExperiment object returned by celda_C, celda_G, or celda_CG.
altExpName	The name for the altExp slot to use. Default "featureSubset".

Value

Character. The celda model. Can be one of "celda_C", "celda_G", or "celda_CG".

Examples

```
data(sceCeldaCG)
celdaModel(sceCeldaCG)
```

`celdaModules` *Get or set the feature module labels from a celda SingleCellExperiment object.*

Description

Return or set the feature module cluster labels determined by celda_G or celda_CG models.

Usage

```
celdaModules(sce, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
celdaModules(sce, altExpName = "featureSubset")

celdaModules(sce, altExpName = "featureSubset") <- value

## S4 replacement method for signature 'SingleCellExperiment'
celdaModules(sce, altExpName = "featureSubset") <- value
```

Arguments

`sce`	A SingleCellExperiment object returned by celda_G, or celda_CG, with the matrix located in the `useAssay` assay slot. Rows represent features and columns represent cells.
`altExpName`	The name for the altExp slot to use. Default "featureSubset".
`value`	Character vector of feature module labels for replacements. Works only if x is a SingleCellExperiment object.

Value

Character vector. Contains feature module labels for each feature in x.

Examples

```
data(sceCeldaCG)
celdaModules(sceCeldaCG)
```

celdaPerplexity *Get perplexity for every model in a celdaList*

Description

Returns perplexity for each model in a celdaList as calculated by 'perplexity().'

Usage

```
celdaPerplexity(celdaList)
```

Arguments

celdaList	An object of class celdaList.

Value

List. Contains one celdaModel object for each of the parameters specified in the 'runParams()' of the provided celda list.

Examples

```
data(celdaCGGridSearchRes)
celdaCGGridModelPerplexities <- celdaPerplexity(celdaCGGridSearchRes)
```

celdaPerplexity,celdaList-method *Get perplexity for every model in a celdaList*

Description

Returns perplexity for each model in a celdaList as calculated by 'perplexity().'

Usage

```
## S4 method for signature 'celdaList'
celdaPerplexity(celdaList)
```

Arguments

celdaList	An object of class celdaList.

Value

List. Contains one celdaModel object for each of the parameters specified in the 'runParams()' of the provided celda list.

Examples

```
data(celdaCGGridSearchRes)
celdaCGGridModelPerplexities <- celdaPerplexity(celdaCGGridSearchRes)
```

`celdaProbabilityMap` *Probability map for a celda model*

Description

Renders probability and relative expression heatmaps to visualize the relationship between features and cell populations (or cell populations and samples).

Usage

```
celdaProbabilityMap(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  level = c("cellPopulation", "sample"),
  ncols = 100,
  col2 = circlize::colorRamp2(c(-2, 0, 2), c("#1E90FF", "#FFFFFF", "#CD2626")),
  title1 = "Absolute probability",
  title2 = "Relative expression",
  showColumnNames = TRUE,
  showRowNames = TRUE,
  rowNamesgp = grid::gpar(fontsize = 8),
  colNamesgp = grid::gpar(fontsize = 12),
  clusterRows = FALSE,
  clusterColumns = FALSE,
  showHeatmapLegend = TRUE,
  heatmapLegendParam = list(title = NULL, legend_height = grid::unit(6, "cm")),
  ...
)

## S4 method for signature 'SingleCellExperiment'
celdaProbabilityMap(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  level = c("cellPopulation", "sample"),
  ncols = 100,
  col2 = circlize::colorRamp2(c(-2, 0, 2), c("#1E90FF", "#FFFFFF", "#CD2626")),
  title1 = "Absolute probability",
  title2 = "Relative expression",
  showColumnNames = TRUE,
  showRowNames = TRUE,
  rowNamesgp = grid::gpar(fontsize = 8),
```

```
  colNamesgp = grid::gpar(fontsize = 12),
  clusterRows = FALSE,
  clusterColumns = FALSE,
  showHeatmapLegend = TRUE,
  heatmapLegendParam = list(title = NULL, legend_height = grid::unit(6, "cm")),
  ...
)
```

Arguments

sce	A SingleCellExperiment object returned by celda_C, celda_G, or celda_CG.
useAssay	A string specifying which assay slot to use. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
level	Character. One of "cellPopulation" or "Sample". "cellPopulation" will display the absolute probabilities and relative normalized expression of each module in each cell population. `level = "cellPopulation"` **only works for celda_CG sce objects**. "sample" will display the absolute probabilities and relative normalized abundance of each cell population in each sample. Default "cellPopulation".
ncols	The number of colors (>1) to be in the color palette of the absolute probability heatmap.
col2	Passed to `col` argument of Heatmap. Set color boundaries and colors for the relative expression heatmap.
title1	Passed to `column_title` argument of Heatmap. Figure title for the absolute probability heatmap.
title2	Passed to `column_title` argument of Heatmap. Figure title for the relative expression heatmap.
showColumnNames	Passed to `show_column_names` argument of Heatmap. Show column names.
showRowNames	Passed to `show_row_names` argument of Heatmap. Show row names.
rowNamesgp	Passed to `row_names_gp` argument of Heatmap. Set row name font.
colNamesgp	Passed to `column_names_gp` argument of Heatmap. Set column name font.
clusterRows	Passed to `cluster_rows` argument of Heatmap. Cluster rows.
clusterColumns	Passed to `cluster_columns` argument of Heatmap. Cluster columns.
showHeatmapLegend	Passed to `show_heatmap_legend` argument of Heatmap. Show heatmap legend.
heatmapLegendParam	Passed to `heatmap_legend_param` argument of Heatmap. Heatmap legend parameters.
...	Additional parameters passed to Heatmap.

Value

A HeatmapList object containing 2 Heatmap-class objects

See Also

celda_C for clustering cells. celda_CG for clustering features and cells

Examples

```
data(sceCeldaCG)
celdaProbabilityMap(sceCeldaCG)
```

`celdatosce` *Convert old celda model object to* `SCE` *object*

Description

Convert a old celda model object (`celda_C`, `celda_G`, or `celda_CG` object) to a SingleCellExperiment object containing celda model information in `metadata` slot. Counts matrix is stored in the `"counts"` assay slot in `assays`.

Usage

```
celdatosce(
  celdaModel,
  counts,
  useAssay = "counts",
  altExpName = "featureSubset"
)

## S4 method for signature 'celda_C'
celdatosce(
  celdaModel,
  counts,
  useAssay = "counts",
  altExpName = "featureSubset"
)

## S4 method for signature 'celda_G'
celdatosce(
  celdaModel,
  counts,
  useAssay = "counts",
  altExpName = "featureSubset"
)

## S4 method for signature 'celda_CG'
celdatosce(
  celdaModel,
  counts,
  useAssay = "counts",
```

```
  altExpName = "featureSubset"
)

## S4 method for signature 'celdaList'
celdatosce(
  celdaModel,
  counts,
  useAssay = "counts",
  altExpName = "featureSubset"
)
```

Arguments

celdaModel	A celdaModel or celdaList object generated using older versions of celda.
counts	A numeric matrix of counts used to generate celdaModel. Dimensions and MD5 checksum will be checked by compareCountMatrix.
useAssay	A string specifying the name of the assay slot to use. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".

Value

A SingleCellExperiment object. Function parameter settings are stored in the metadata "celda_parameters" slot. Columns celda_sample_label and celda_cell_cluster in colData contain sample labels and celda cell population clusters. Column celda_feature_module in rowData contain feature modules.

Examples

```
data(celdaCMod, celdaCSim)
sce <- celdatosce(celdaCMod, celdaCSim$counts)
data(celdaGMod, celdaGSim)
sce <- celdatosce(celdaGMod, celdaGSim$counts)
data(celdaCGMod, celdaCGSim)
sce <- celdatosce(celdaCGMod, celdaCGSim$counts)
data(celdaCGGridSearchRes, celdaCGSim)
sce <- celdatosce(celdaCGGridSearchRes, celdaCGSim$counts)
```

---

celdaTsne *t-Distributed Stochastic Neighbor Embedding (t-SNE) dimension reduction for celda* sce *object*

Description

Embeds cells in two dimensions using Rtsne based on a celda model. For celda_C sce objects, PCA on the normalized counts is used to reduce the number of features before applying t-SNE. For celda_CG and celda_G sce objects, tSNE is run on module probabilities to reduce the number of features instead of using PCA. Module probabilities are square-root transformed before applying tSNE.

Usage

```
celdaTsne(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  maxCells = NULL,
  minClusterSize = 100,
  initialDims = 20,
  modules = NULL,
  perplexity = 20,
  maxIter = 2500,
  normalize = "proportion",
  scaleFactor = NULL,
  transformationFun = sqrt,
  seed = 12345
)

## S4 method for signature 'SingleCellExperiment'
celdaTsne(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  maxCells = NULL,
  minClusterSize = 100,
  initialDims = 20,
  modules = NULL,
  perplexity = 20,
  maxIter = 2500,
  normalize = "proportion",
  scaleFactor = NULL,
  transformationFun = sqrt,
  seed = 12345
)
```

Arguments

sce	A SingleCellExperiment object returned by celda_C, celda_G, or celda_CG.
useAssay	A string specifying which assay slot to use. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
maxCells	Integer. Maximum number of cells to plot. Cells will be randomly subsampled if `ncol(counts) > maxCells`. Larger numbers of cells requires more memory. If `NULL`, no subsampling will be performed. Default `NULL`.
minClusterSize	Integer. Do not subsample cell clusters below this threshold. Default 100.
initialDims	Integer. PCA will be used to reduce the dimensionality of the dataset. The top 'initialDims' principal components will be used for tSNE. Default 20.
modules	Integer vector. Determines which feature modules to use for tSNE. If `NULL`, all modules will be used. Default `NULL`.

perplexity — Numeric. Perplexity parameter for tSNE. Default 20.

maxIter — Integer. Maximum number of iterations in tSNE generation. Default 2500.

normalize — Character. Passed to normalizeCounts in normalization step. Divides counts by the library sizes for each cell. One of 'proportion', 'cpm', 'median', or 'mean'. 'proportion' uses the total counts for each cell as the library size. 'cpm' divides the library size of each cell by one million to produce counts per million. 'median' divides the library size of each cell by the median library size across all cells. 'mean' divides the library size of each cell by the mean library size across all cells.

scaleFactor — Numeric. Sets the scale factor for cell-level normalization. This scale factor is multiplied to each cell after the library size of each cell had been adjusted in `normalize`. Default `NULL` which means no scale factor is applied.

transformationFun — Function. Applys a transformation such as 'sqrt', 'log', 'log2', 'log10', or 'log1p'. If `NULL`, no transformation will be applied. Occurs after applying normalization and scale factor. Default `NULL`.

seed — Integer. Passed to with_seed. For reproducibility, a default value of 12345 is used. If NULL, no calls to with_seed are made.

Value

`sce` with t-SNE coordinates (columns "celda_tSNE1" & "celda_tSNE2") added to `reducedDim(sce, "celda_tSNE")`.

Examples

```
data(sceCeldaCG)
tsneRes <- celdaTsne(sceCeldaCG)
```

---

celdaUmap — *Uniform Manifold Approximation and Projection (UMAP) dimension reduction for celda* `sce` *object*

Description

Embeds cells in two dimensions using umap based on a celda model. For celda_C `sce` objects, PCA on the normalized counts is used to reduce the number of features before applying UMAP. For celda_CG `sce` object, UMAP is run on module probabilities to reduce the number of features instead of using PCA. Module probabilities are square-root transformed before applying UMAP.

Usage

```
celdaUmap(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
```

```
  maxCells = NULL,
  minClusterSize = 100,
  modules = NULL,
  seed = 12345,
  nNeighbors = 30,
  minDist = 0.75,
  spread = 1,
  pca = TRUE,
  initialDims = 50,
  normalize = "proportion",
  scaleFactor = NULL,
  transformationFun = sqrt,
  cores = 1,
  ...
)

## S4 method for signature 'SingleCellExperiment'
celdaUmap(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  maxCells = NULL,
  minClusterSize = 100,
  modules = NULL,
  seed = 12345,
  nNeighbors = 30,
  minDist = 0.75,
  spread = 1,
  pca = TRUE,
  initialDims = 50,
  normalize = "proportion",
  scaleFactor = NULL,
  transformationFun = sqrt,
  cores = 1,
  ...
)
```

Arguments

sce	A SingleCellExperiment object returned by celda_C, celda_G, or celda_CG.
useAssay	A string specifying which assay slot to use. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
maxCells	Integer. Maximum number of cells to plot. Cells will be randomly subsampled if `ncol(sce) > maxCells`. Larger numbers of cells requires more memory. If NULL, no subsampling will be performed. Default NULL.
minClusterSize	Integer. Do not subsample cell clusters below this threshold. Default 100.
modules	Integer vector. Determines which features modules to use for UMAP. If NULL, all modules will be used. Default NULL.

`seed` Integer. Passed to with_seed. For reproducibility, a default value of 12345 is used. If NULL, no calls to with_seed are made.

`nNeighbors` The size of local neighborhood used for manifold approximation. Larger values result in more global views of the manifold, while smaller values result in more local data being preserved. Default 30. See umap for more information.

`minDist` The effective minimum distance between embedded points. Smaller values will result in a more clustered/clumped embedding where nearby points on the manifold are drawn closer together, while larger values will result on a more even dispersal of points. Default 0.75. See umap for more information.

`spread` The effective scale of embedded points. In combination with `min_dist`, this determines how clustered/clumped the embedded points are. Default 1. See umap for more information.

`pca` Logical. Whether to perform dimensionality reduction with PCA before UMAP. Only works for celda_C `sce` objects.

`initialDims` Integer. Number of dimensions from PCA to use as input in UMAP. Default 50. Only works for celda_C `sce` objects.

`normalize` Character. Passed to normalizeCounts in normalization step. Divides counts by the library sizes for each cell. One of 'proportion', 'cpm', 'median', or 'mean'. 'proportion' uses the total counts for each cell as the library size. 'cpm' divides the library size of each cell by one million to produce counts per million. 'median' divides the library size of each cell by the median library size across all cells. 'mean' divides the library size of each cell by the mean library size across all cells.

`scaleFactor` Numeric. Sets the scale factor for cell-level normalization. This scale factor is multiplied to each cell after the library size of each cell had been adjusted in `normalize`. Default `NULL` which means no scale factor is applied.

`transformationFun` Function. Applys a transformation such as 'sqrt', 'log', 'log2', 'log10', or 'log1p'. If `NULL`, no transformation will be applied. Occurs after applying normalization and scale factor. Default `NULL`.

`cores` Number of threads to use. Default 1.

`...` Additional parameters to pass to umap.

Value

`sce` with UMAP coordinates (columns "celda_UMAP1" & "celda_UMAP2") added to `reducedDim(sce, "celda_UMAP")`.

Examples

```
data(sceCeldaCG)
umapRes <- celdaUmap(sceCeldaCG)
```

`clusterProbability` *Get the conditional probabilities of cell in subpopulations from celda model*

Description

Calculate the conditional probability of each cell belonging to each subpopulation given all other cell cluster assignments and/or each feature belonging to each module given all other feature cluster assignments in a celda model.

Usage

```
clusterProbability(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  log = FALSE
)

## S4 method for signature 'SingleCellExperiment'
clusterProbability(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  log = FALSE
)
```

Arguments

`sce`	A SingleCellExperiment object returned by celda_C, celda_G, or celda_CG, with the matrix located in the `useAssay` assay slot. Rows represent features and columns represent cells.
`useAssay`	A string specifying which assay slot to use. Default "counts".
`altExpName`	The name for the altExp slot to use. Default "featureSubset".
`log`	Logical. If `FALSE`, then the normalized conditional probabilities will be returned. If `TRUE`, then the unnormalized log probabilities will be returned. Default `FALSE`.

Value

A list containging a matrix for the conditional cell subpopulation cluster and/or feature module probabilities.

See Also

‘celda_C()‘ for clustering cells

Examples

```
data(sceCeldaCG)
clusterProb <- clusterProbability(sceCeldaCG, log = TRUE)
data(sceCeldaC)
clusterProb <- clusterProbability(sceCeldaC)
```

`compareCountMatrix` *Check count matrix consistency*

Description

Checks if the counts matrix is the same one used to generate the celda model object by comparing dimensions and MD5 checksum.

Usage

```
compareCountMatrix(counts, celdaMod, errorOnMismatch = TRUE)

## S4 method for signature 'ANY,celdaModel'
compareCountMatrix(counts, celdaMod, errorOnMismatch = TRUE)

## S4 method for signature 'ANY,celdaList'
compareCountMatrix(counts, celdaMod, errorOnMismatch = TRUE)
```

Arguments

`counts`	Integer , Numeric, or Sparse matrix. Rows represent features and columns represent cells.
`celdaMod`	A `celdaModel` or `celdaList` object.
`errorOnMismatch`	Logical. Whether to throw an error in the event of a mismatch. Default TRUE.

Value

Returns TRUE if provided count matrix matches the one used in the celda object and/or `errorOnMismatch = FALSE`, FALSE otherwise.

Examples

```
data(celdaCGSim, celdaCGMod)
compareCountMatrix(celdaCGSim$counts, celdaCGMod, errorOnMismatch = FALSE)
data(celdaCGSim, celdaCGGridSearchRes)
compareCountMatrix(celdaCGSim$counts, celdaCGGridSearchRes,
    errorOnMismatch = FALSE)
```

contaminationSim *contaminationSim*

Description

A toy contamination data generated by simulateContamination

Usage

```
contaminationSim
```

Format

A list

countChecksum *Get the MD5 hash of the count matrix from the celdaList*

Description

Returns the MD5 hash of the count matrix used to generate the celdaList.

Usage

```
countChecksum(celdaList)
```

Arguments

celdaList	An object of class celdaList.

Value

A character string of length 32 containing the MD5 digest of the count matrix.

Examples

```
data(celdaCGGridSearchRes)
countChecksum <- countChecksum(celdaCGGridSearchRes)
```

countChecksum,celdaList-method *Get the MD5 hash of the count matrix from the celdaList*

Description

Returns the MD5 hash of the count matrix used to generate the celdaList.

Usage

```
## S4 method for signature 'celdaList'
countChecksum(celdaList)
```

Arguments

celdaList	An object of class celdaList.

Value

A character string of length 32 containing the MD5 digest of the count matrix.

Examples

```
data(celdaCGGridSearchRes)
countChecksum <- countChecksum(celdaCGGridSearchRes)
```

decontX *Contamination estimation with decontX*

Description

Identifies contamination from factors such as ambient RNA in single cell genomic datasets.

Usage

```
decontX(x, ...)

## S4 method for signature 'SingleCellExperiment'
decontX(
  x,
  assayName = "counts",
  z = NULL,
  batch = NULL,
  background = NULL,
  bgAssayName = NULL,
  bgBatch = NULL,
```

```
  maxIter = 500,
  delta = c(10, 10),
  estimateDelta = TRUE,
  convergence = 0.001,
  iterLogLik = 10,
  varGenes = 5000,
  dbscanEps = 1,
  seed = 12345,
  logfile = NULL,
  verbose = TRUE
)

## S4 method for signature 'ANY'
decontX(
  x,
  z = NULL,
  batch = NULL,
  background = NULL,
  bgBatch = NULL,
  maxIter = 500,
  delta = c(10, 10),
  estimateDelta = TRUE,
  convergence = 0.001,
  iterLogLik = 10,
  varGenes = 5000,
  dbscanEps = 1,
  seed = 12345,
  logfile = NULL,
  verbose = TRUE
)
```

Arguments

x	A numeric matrix of counts or a SingleCellExperiment with the matrix located in the assay slot under assayName. Cells in each batch will be subsetted and converted to a sparse matrix of class dgCMatrix from package Matrix before analysis. This object should only contain filtered cells after cell calling. Empty cell barcodes (low expression droplets before cell calling) are not needed to run DecontX.
...	For the generic, further arguments to pass to each method.
assayName	Character. Name of the assay to use if x is a SingleCellExperiment.
z	Numeric or character vector. Cell cluster labels. If NULL, PCA will be used to reduce the dimensionality of the dataset initially, 'umap' from the 'uwot' package will be used to further reduce the dataset to 2 dimenions and the 'dbscan' function from the 'dbscan' package will be used to identify clusters of broad cell types. Default NULL.
batch	Numeric or character vector. Batch labels for cells. If batch labels are supplied, DecontX is run on cells from each batch separately. Cells run in different

channels or assays should be considered different batches. Default NULL.

background — A numeric matrix of counts or a SingleCellExperiment with the matrix located in the assay slot under assayName. It should have the same data format as x except it contains the empty droplets instead of cells. When supplied, empirical distribution of transcripts from these empty droplets will be used as the contamination distribution. Default NULL.

bgAssayName — Character. Name of the assay to use if background is a SingleCellExperiment. Default to same as assayName.

bgBatch — Numeric or character vector. Batch labels for background. Its unique values should be the same as those in batch, such that each batch of cells have their corresponding batch of empty droplets as background, pointed by this parameter. Default to NULL.

maxIter — Integer. Maximum iterations of the EM algorithm. Default 500.

delta — Numeric Vector of length 2. Concentration parameters for the Dirichlet prior for the contamination in each cell. The first element is the prior for the native counts while the second element is the prior for the contamination counts. These essentially act as pseudocounts for the native and contamination in each cell. If estimateDelta = TRUE, this is only used to produce a random sample of proportions for an initial value of contamination in each cell. Then fit_dirichlet is used to update delta in each iteration. If estimateDelta = FALSE, then delta is fixed with these values for the entire inference procedure. Fixing delta and setting a high number in the second element will force decontX to be more aggressive and estimate higher levels of contamination at the expense of potentially removing native expression. Default c(10, 10).

estimateDelta — Boolean. Whether to update delta at each iteration.

convergence — Numeric. The EM algorithm will be stopped if the maximum difference in the contamination estimates between the previous and current iterations is less than this. Default 0.001.

iterLogLik — Integer. Calculate log likelihood every iterLogLik iteration. Default 10.

varGenes — Integer. The number of variable genes to use in dimensionality reduction before clustering. Variability is calcualted using modelGeneVar function from the 'scran' package. Used only when z is not provided. Default 5000.

dbscanEps — Numeric. The clustering resolution parameter used in 'dbscan' to estimate broad cell clusters. Used only when z is not provided. Default 1.

seed — Integer. Passed to with_seed. For reproducibility, a default value of 12345 is used. If NULL, no calls to with_seed are made.

logfile — Character. Messages will be redirected to a file named 'logfile'. If NULL, messages will be printed to stdout. Default NULL.

verbose — Logical. Whether to print log messages. Default TRUE.

Value

If x is a matrix-like object, a list will be returned with the following items:

decontXcounts: The decontaminated matrix. Values obtained from the variational inference procedure may be non-integer. However, integer counts can be obtained by rounding, e.g. round(decontXcounts).

`contamination`: Percentage of contamination in each cell.

`estimates`: List of estimated parameters for each batch. If z was not supplied, then the UMAP coordinates used to generated cell cluster labels will also be stored here.

`z`: Cell population/cluster labels used for analysis.

`runParams`: List of arguments used in the function call.

If `x` is a SingleCellExperiment, then the decontaminated counts will be stored as an assay and can be accessed with `decontXcounts(x)`. The contamination values and cluster labels will be stored in `colData(x)`. `estimates` and `runParams` will be stored in `metadata(x)$decontX`. The UMAPs used to generated cell cluster labels will be stored in `reducedDims` slot in `x`.

Author(s)

Shiyi Yang, Yuan Yin, Joshua Campbell

Examples

```
# Generate matrix with contamination
s <- simulateContamination(seed = 12345)

library(SingleCellExperiment)
sce <- SingleCellExperiment(list(counts = s$observedCounts))
sce <- decontX(sce)

# Plot contamination on UMAP
plotDecontXContamination(sce)

# Plot decontX cluster labels
umap <- reducedDim(sce)
plotDimReduceCluster(x = sce$decontX_clusters,
    dim1 = umap[, 1], dim2 = umap[, 2], )

# Plot percentage of marker genes detected
# in each cell cluster before decontamination
s$markers
plotDecontXMarkerPercentage(sce, markers = s$markers, assayName = "counts")

# Plot percentage of marker genes detected
# in each cell cluster after contamination
plotDecontXMarkerPercentage(sce, markers = s$markers,
                            assayName = "decontXcounts")

# Plot percentage of marker genes detected in each cell
# comparing original and decontaminated counts side-by-side
plotDecontXMarkerPercentage(sce, markers = s$markers,
                            assayName = c("counts", "decontXcounts"))

# Plot raw counts of indiviual markers genes before
# and after decontamination
plotDecontXMarkerExpression(sce, unlist(s$markers))
```

decontXcounts *Get or set decontaminated counts matrix*

Description

Gets or sets the decontaminated counts matrix from a a SingleCellExperiment object.

Usage

```
decontXcounts(object, ...)

decontXcounts(object, ...) <- value

## S4 method for signature 'SingleCellExperiment'
decontXcounts(object, ...)

## S4 replacement method for signature 'SingleCellExperiment'
decontXcounts(object, ...) <- value
```

Arguments

object	A SingleCellExperiment object.
...	For the generic, further arguments to pass to each method.
value	A matrix to save as an assay called decontXcounts

Value

If getting, the assay from object with the name decontXcounts will be returned. If setting, a SingleCellExperiment object will be returned with decontXcounts listed in the assay slot.

See Also

assay and assay<-

distinctColors *Create a color palette*

Description

Generate a palette of 'n' distinct colors.

Usage

```
distinctColors(
  n,
 hues = c("red", "cyan", "orange", "blue", "yellow", "purple", "green", "magenta"),
  saturationRange = c(0.7, 1),
  valueRange = c(0.7, 1)
)
```

Arguments

n	Integer. Number of colors to generate.
hues	Character vector. Colors available from 'colors()'. These will be used as the base colors for the clustering scheme in HSV. Different saturations and values will be generated for each hue. Default c("red", "cyan", "orange", "blue", "yellow", "purple", "green", "magenta").
saturationRange	Numeric vector. A vector of length 2 denoting the saturation for HSV. Values must be in [0,1]. Default: c(0.25, 1).
valueRange	Numeric vector. A vector of length 2 denoting the range of values for HSV. Values must be in [0,1]. Default: 'c(0.5, 1)'.

Value

A vector of distinct colors that have been converted to HEX from HSV.

Examples

```
colorPal <- distinctColors(6) # can be used in plotting functions
```

---

eigenMatMultInt *Fast matrix multiplication for double x int*

Description

Fast matrix multiplication for double x int

Usage

```
eigenMatMultInt(A, B)
```

Arguments

A	a double matrix
B	an integer matrix

Value

An integer matrix representing the product of A and B

eigenMatMultNumeric *Fast matrix multiplication for double x double*

Description

Fast matrix multiplication for double x double

Usage

```
eigenMatMultNumeric(A, B)
```

Arguments

A	a double matrix
B	an integer matrix

Value

An integer matrix representing the product of A and B

factorizeMatrix *Generate factorized matrices showing each feature's influence on cell / gene clustering*

Description

Generates factorized matrices showing the contribution of each feature in each cell population or each cell population in each sample.

Usage

```
factorizeMatrix(
  x,
  celdaMod,
  useAssay = "counts",
  altExpName = "featureSubset",
  type = c("counts", "proportion", "posterior")
)

## S4 method for signature 'SingleCellExperiment,ANY'
factorizeMatrix(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  type = c("counts", "proportion", "posterior")
```

```
)

## S4 method for signature 'ANY,celda_CG'
factorizeMatrix(x, celdaMod, type = c("counts", "proportion", "posterior"))

## S4 method for signature 'ANY,celda_C'
factorizeMatrix(x, celdaMod, type = c("counts", "proportion", "posterior"))

## S4 method for signature 'ANY,celda_G'
factorizeMatrix(x, celdaMod, type = c("counts", "proportion", "posterior"))
```

Arguments

x	Can be one of • A SingleCellExperiment object returned by celda_C, celda_G or celda_CG, with the matrix located in the useAssay assay slot in altExp(x, altExpName). Rows represent features and columns represent cells. • Integer counts matrix. Rows represent features and columns represent cells. This matrix should be the same as the one used to generate celdaMod.
celdaMod	Celda model object. Only works if x is an integer counts matrix.
useAssay	A string specifying which assay slot to use if x is a SingleCellExperiment object. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
type	Character vector. A vector containing one or more of "counts", "proportion", or "posterior". "counts" returns the raw number of counts for each factorized matrix. "proportions" returns the normalized probabilities for each factorized matrix, which are calculated by dividing the raw counts in each factorized matrix by the total counts in each column. "posterior" returns the posterior estimates which include the addition of the Dirichlet concentration parameter (essentially as a pseudocount). Default "counts".

Value

For celda_CG model, A list with elements for "counts", "proportions", or "posterior" probabilities. Each element will be a list containing factorized matrices for "module", "cellPopulation", and "sample". Additionally, the contribution of each module in each individual cell will be included in the "cell" element of "counts" and "proportions" elements.

For celda_C model, a list with elements for "counts", "proportions", or "posterior" probabilities. Each element will be a list containing factorized matrices for "module" and "sample".

For celda_G model, a list with elements for "counts", "proportions", or "posterior" probabilities. Each element will be a list containing factorized matrices for "module" and "cell".

Examples

```
data(sceCeldaCG)
factorizedMatrices <- factorizeMatrix(sceCeldaCG, type = "posterior")
data(celdaCGSim, celdaCGMod)
```

```
factorizedMatrices <- factorizeMatrix(
  celdaCGSim$counts,
  celdaCGMod,
  "posterior")
data(celdaCSim, celdaCMod)
factorizedMatrices <- factorizeMatrix(
  celdaCSim$counts,
  celdaCMod, "posterior"
)
data(celdaGSim, celdaGMod)
factorizedMatrices <- factorizeMatrix(
  celdaGSim$counts,
  celdaGMod, "posterior"
)
```

`fastNormProp` *Fast normalization for numeric matrix*

Description

Fast normalization for numeric matrix

Usage

```
fastNormProp(R_counts, R_alpha)
```

Arguments

`R_counts`	An integer matrix
`R_alpha`	A double value to be added to the matrix as a pseudocount

Value

A numeric matrix where the columns have been normalized to proportions

---

`fastNormPropLog` *Fast normalization for numeric matrix*

Description

Fast normalization for numeric matrix

Usage

```
fastNormPropLog(R_counts, R_alpha)
```

Arguments

R_counts	An integer matrix
R_alpha	A double value to be added to the matrix as a pseudocount

Value

A numeric matrix where the columns have been normalized to proportions

---

fastNormPropSqrt *Fast normalization for numeric matrix*

Description

Fast normalization for numeric matrix

Usage

```
fastNormPropSqrt(R_counts, R_alpha)
```

Arguments

R_counts	An integer matrix
R_alpha	A double value to be added to the matrix as a pseudocount

Value

A numeric matrix where the columns have been normalized to proportions

---

featureModuleLookup *Obtain the gene module of a gene of interest*

Description

This function will output the corresponding feature module for a specified vector of genes from a celda_CG or celda_G `celdaModel`. `features` must match the rownames of `sce`.

Usage

```
featureModuleLookup(
  sce,
  features,
  altExpName = "featureSubset",
  exactMatch = TRUE,
  by = "rownames"
)

## S4 method for signature 'SingleCellExperiment'
featureModuleLookup(
  sce,
  features,
  altExpName = "featureSubset",
  exactMatch = TRUE,
  by = "rownames"
)
```

Arguments

sce	A SingleCellExperiment object returned by celda_G, or celda_CG, with the matrix located in the useAssay assay slot. Rows represent features and columns represent cells.
features	Character vector. Identify feature modules for the specified feature names. feature must match the rownames of sce.
altExpName	The name for the altExp slot to use. Default "featureSubset".
exactMatch	Logical. Whether to look for exactMatch of the gene name within counts matrix. Default TRUE.
by	Character. Where to search for features in the sce object. If set to "rownames" then the features will be searched for among rownames(sce). This can also be set to one of the colnames of rowData(sce). Default "rownames".

Value

Numeric vector containing the module numbers for each feature. If the feature was not found, then an NA value will be returned in that position. If no features were found, then an error will be given.

Examples

```
data(sceCeldaCG)
module <- featureModuleLookup(sce = sceCeldaCG,
    features = c("Gene_1", "Gene_XXX"))
```

`featureModuleTable` *Output a feature module table*

Description

Creates a table that contains the list of features in each feature module.

Usage

```
featureModuleTable(
  sce,
  useAssay = "counts",
  altExpName = "featureSubset",
  displayName = NULL,
  outputFile = NULL
)
```

Arguments

`sce`	A SingleCellExperiment object returned by celda_G, or celda_CG, with the matrix located in the `useAssay` assay slot. Rows represent features and columns represent cells.
`useAssay`	A string specifying which assay slot to use. Default "counts".
`altExpName`	The name for the altExp slot to use. Default "featureSubset".
`displayName`	Character. The column name of `rowData(sce)` that specifies the display names for the features. Default `NULL`, which displays the row names.
`outputFile`	File name for feature module table. If NULL, file will not be created. Default NULL.

Value

Matrix. Contains a list of features per each column (feature module)

Examples

```
data(sceCeldaCG)
featureModuleTable(sceCeldaCG)
```

findMarkersTree *Generate marker decision tree from single-cell clustering output*

Description

Create a decision tree that identifies gene markers for given cell populations. The algorithm uses a decision tree procedure to generate a set of rules for each cell cluster defined by single-cell clustering. Splits are determined by one of two metrics at each split: a one-off metric to determine rules for identifying clusters by a single feature, and a balanced metric to determine rules for identifying sets of similar clusters.

Usage

```
findMarkersTree(
  features,
  class,
  oneoffMetric = c("modified F1", "pairwise AUC"),
  metaclusters,
  featureLabels,
  counts,
  celda,
  seurat,
  threshold = 0.9,
  reuseFeatures = FALSE,
  altSplit = TRUE,
  consecutiveOneoff = FALSE,
  autoMetaclusters = TRUE,
  seed = 12345
)
```

Arguments

features	features-by-samples numeric matrix, e.g. counts matrix.
class	Vector of cell cluster labels.
oneoffMetric	A character string. What one-off metric to run, either 'modified F1' or 'pairwise AUC'. Default is 'modified F1'.
metaclusters	List where each element is a metacluster (e.g. known cell type) and all the clusters within that metacluster (e.g. subtypes).
featureLabels	Vector of feature assignments, e.g. which cluster does each gene belong to? Useful when using clusters of features (e.g. gene modules or Seurat PCs) and user wishes to expand tree results to individual features (e.g. score individual genes within marker gene modules).
counts	Numeric counts matrix. Useful when using clusters of features (e.g. gene modules) and user wishes to expand tree results to individual features (e.g. score individual genes within marker gene modules). Row names should be individual feature names.

`celda` A *celda_CG* or *celda_C* object. Counts matrix has to be provided as well.

`seurat` A seurat object. Note that the seurat functions *RunPCA* and *FindClusters* must have been run on the object.

`threshold` Numeric between 0 and 1. The threshold for the oneoff metric. Smaller values will result in more one-off splits. Default is 0.90.

`reuseFeatures` Logical. Whether or not a feature can be used more than once on the same cluster. Default is TRUE.

`altSplit` Logical. Whether or not to force a marker for clusters that are solely defined by the absence of markers. Default is TRUE.

`consecutiveOneoff` Logical. Whether or not to allow one-off splits at consecutive brances. Default is FALSE.

`autoMetaclusters` Logical. Whether to identify metaclusters prior to creating the tree based on the distance between clusters in a UMAP dimensionality reduction projection. A metacluster is simply a large cluster that includes several clusters within it. Default is TRUE.

`seed` Numeric. Seed used to enable reproducible UMAP results for identifying meta-clusters. Default is 12345.

Value

A named list with six elements:

- rules - A named list with one data frame for every label. Each data frame has five columns and gives the set of rules for disinguishing each label.
  - feature - Marker feature, e.g. marker gene name.
  - direction - Relationship to feature value. -1 if cluster is down-regulated for this feature, 1 if cluster is up-regulated.
  - stat - The performance value returned by the splitting metric for this split.
  - statUsed - Which performance metric was used. "Split" if information gain and "One-off" if one-off.
  - level - The level of the tree at which is rule was defined. 1 is the level of the first split of the tree.
  - metacluster - Optional. If metaclusters were used, the metacluster this rule is applied to.
- dendro - A dendrogram object of the decision tree output. Plot with plotDendro()
- classLabels - A vector of the class labels used in the model, i.e. cell cluster labels.
- metaclusterLabels - A vector of the metacluster labels used in the model
- prediction - A character vector of label of predictions of the training data using the final model. "MISSING" if label prediction was ambiguous.
- performance - A named list denoting the training performance of the model:
  - accuracy - (number correct/number of samples) for the whole set of samples.
  - balAcc - mean sensitivity across all clusters
  - meanPrecision - mean precision across all clusters

- correct - the number of correct predictions of each cluster
- sizes - the number of actual counts of each cluster
- sensitivity - the sensitivity of the prediciton of each cluster
- precision - the precision of the prediciton of each cluster

Examples

```
# Generate simulated single-cell dataset using celda
sce <- celda::simulateCells("celda_CG", K = 4, L = 10, G = 100)

# Select top features
sce <- selectFeatures(sce)

# Celda clustering into 5 clusters & 10 modules
sce <- celda_CG(sce, K=5, L=10, verbose=FALSE)

# Get features matrix and cluster assignments
factorizedCounts <- factorizeMatrix(sce, type = "counts")
featureMatrix <- factorizedCounts$counts$cell
classes <- as.integer(celdaClusters(sce))

# Generate Decision Tree
DecTree <- findMarkersTree(featureMatrix, classes)

# Plot dendrogram
plotDendro(DecTree)
```

---

geneSetEnrich *Gene set enrichment*

Description

Identify and return significantly-enriched terms for each gene module in a Celda object or a SingleCellExperiment object. Performs gene set enrichment analysis for Celda identified modules using the enrichr.

Usage

```
geneSetEnrich(
  x,
  celdaModel,
  useAssay = "counts",
  altExpName = "featureSubset",
  databases,
  fdr = 0.05
)
```

```
## S4 method for signature 'SingleCellExperiment'
geneSetEnrich(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  databases,
  fdr = 0.05
)

## S4 method for signature 'matrix'
geneSetEnrich(x, celdaModel, databases, fdr = 0.05)
```

Arguments

x	A numeric matrix of counts or a SingleCellExperiment with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells. Rownames of the matrix or SingleCellExperiment object should be gene names.
celdaModel	Celda object of class celda_G or celda_CG.
useAssay	A string specifying which assay slot to use if x is a SingleCellExperiment object. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
databases	Character vector. Name of reference database. Available databases can be viewed by listEnrichrDbs.
fdr	False discovery rate (FDR). Numeric. Cutoff value for adjusted p-value, terms with FDR below this value are considered significantly enriched.

Value

List of length 'L' where each member contains the significantly enriched terms for the corresponding module.

Author(s)

Ahmed Youssef, Zhe Wang

Examples

```
library(M3DExampleData)
counts <- M3DExampleData::Mmus_example_list$data
# subset 500 genes for fast clustering
counts <- counts[seq(1501, 2000), ]
# cluster genes into 10 modules for quick demo
sce <- celda_G(x = as.matrix(counts), L = 10, verbose = FALSE)
gse <- geneSetEnrich(sce,
  databases = c("GO_Biological_Process_2018", "GO_Molecular_Function_2018"))
```

getDecisions *Gets cluster estimates using rules generated by 'celda::findMarkersTree'*

Description

Get decisions for a matrix of features. Estimate cell cluster membership using feature matrix input.

Usage

```
getDecisions(rules, features)
```

Arguments

rules	List object. The 'rules' element from 'findMarkersTree' output. Returns NA if cluster estimation was ambiguous.
features	A L(features) by N(samples) numeric matrix.

Value

A character vector of label predicitions.

logLikelihood *Calculate the Log-likelihood of a celda model*

Description

Calculate the log-likelihood for cell population and feature module cluster assignments on the count matrix, per celda model.

Usage

```
logLikelihood(x, celdaMod, useAssay = "counts", altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment,ANY'
logLikelihood(x, useAssay = "counts", altExpName = "featureSubset")

## S4 method for signature 'matrix,celda_C'
logLikelihood(x, celdaMod)

## S4 method for signature 'matrix,celda_G'
logLikelihood(x, celdaMod)

## S4 method for signature 'matrix,celda_CG'
logLikelihood(x, celdaMod)
```

Arguments

x	A SingleCellExperiment object returned by celda_C, celda_G, or celda_CG, with the matrix located in the useAssay assay slot. Rows represent features and columns represent cells.
celdaMod	celda model object. Ignored if x is a SingleCellExperiment object.
useAssay	A string specifying which assay slot to use. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".

Value

The log-likelihood of the cluster assignment for the provided SingleCellExperiment.

See Also

'celda_C()' for clustering cells

Examples

```
data(sceCeldaC, sceCeldaCG)
loglikC <- logLikelihood(sceCeldaC)
loglikCG <- logLikelihood(sceCeldaCG)
```

---

logLikelihoodHistory *Get log-likelihood history*

Description

Retrieves the complete log-likelihood from all iterations of Gibbs sampling used to generate a celda model.

Usage

```
logLikelihoodHistory(x, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
logLikelihoodHistory(x, altExpName = "featureSubset")

## S4 method for signature 'celdaModel'
logLikelihoodHistory(x)
```

Arguments

x	A SingleCellExperiment object returned by celda_C, celda_G, or celda_CG, or a celda model object.
altExpName	The name for the altExp slot to use. Default "featureSubset".

Value

Numeric. The log-likelihood at each step of Gibbs sampling used to generate the model.

Examples

```
data(sceCeldaCG)
logLikelihoodHistory(sceCeldaCG)
data(celdaCGMod)
logLikelihoodHistory(celdaCGMod)
```

`matrixNames` *Get feature, cell and sample names from a celdaModel*

Description

Retrieves the row, column, and sample names used to generate a celdaModel.

Usage

```
matrixNames(celdaMod)

## S4 method for signature 'celdaModel'
matrixNames(celdaMod)
```

Arguments

`celdaMod`	celdaModel. Options available in 'celda::availableModels'.

Value

List. Contains row, column, and sample character vectors corresponding to the values provided when the celdaModel was generated.

Examples

```
data(celdaCGMod)
matrixNames(celdaCGMod)
```

moduleHeatmap *Heatmap for featureModules*

Description

Renders a heatmap for selected `featureModule`. Cells are ordered from those with the lowest probability of the module on the left to the highest probability on the right. Features are ordered from those with the highest probability in the module on the top to the lowest probability on the bottom.

Usage

```
moduleHeatmap(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  modules = NULL,
  featureModule = NULL,
  col = circlize::colorRamp2(c(-2, 0, 2), c("#1E90FF", "#FFFFFF", "#CD2626")),
  topCells = 100,
  topFeatures = NULL,
  normalizedCounts = NA,
  normalize = "proportion",
  transformationFun = sqrt,
  scaleRow = scale,
  showFeatureNames = TRUE,
  displayName = NULL,
  trim = c(-2, 2),
  rowFontSize = NULL,
  showHeatmapLegend = FALSE,
  showTopAnnotationLegend = FALSE,
  showTopAnnotationName = FALSE,
  topAnnotationHeight = 5,
  showModuleLabel = TRUE,
  moduleLabel = "auto",
  moduleLabelSize = NULL,
  byrow = TRUE,
  top = NA,
  unit = "mm",
  ncol = NULL,
  useRaster = TRUE,
  returnAsList = FALSE,
  ...
)

## S4 method for signature 'SingleCellExperiment'
moduleHeatmap(
```

```
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  modules = NULL,
  featureModule = NULL,
  col = circlize::colorRamp2(c(-2, 0, 2), c("#1E90FF", "#FFFFFF", "#CD2626")),
  topCells = 100,
  topFeatures = NULL,
  normalizedCounts = NA,
  normalize = "proportion",
  transformationFun = sqrt,
  scaleRow = scale,
  showFeatureNames = TRUE,
  displayName = NULL,
  trim = c(-2, 2),
  rowFontSize = NULL,
  showHeatmapLegend = FALSE,
  showTopAnnotationLegend = FALSE,
  showTopAnnotationName = FALSE,
  topAnnotationHeight = 5,
  showModuleLabel = TRUE,
  moduleLabel = "auto",
  moduleLabelSize = NULL,
  byrow = TRUE,
  top = NA,
  unit = "mm",
  ncol = NULL,
  useRaster = TRUE,
  returnAsList = FALSE,
  ...
)
```

Arguments

x	A numeric matrix of counts or a SingleCellExperiment with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells. Celda results must be present under metadata(altExp(x, altExpName)).
useAssay	A string specifying which assay slot to use if x is a SingleCellExperiment object. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
modules	Integer Vector. The featureModule(s) to display. Multiple modules can be included in a vector. Default NULL which plots all module heatmaps.
featureModule	Same as modules. Either can be used to specify the modules to display.
col	Passed to Heatmap. Set color boundaries and colors.
topCells	Integer. Number of cells with the highest and lowest probabilities for each module to include in the heatmap. For example, if topCells = 50, the 50 cells with the lowest probabilities and the 50 cells with the highest probabilities for each featureModule will be included. If NULL, all cells will be plotted. Default 100.

`topFeatures` Integer. Plot 'topFeatures' features with the highest probabilities in the module heatmap for each featureModule. If `NULL`, plot all features in the module. Default `NULL`.

`normalizedCounts`
Integer matrix. Rows represent features and columns represent cells. If you have a normalized matrix result from normalizeCounts, you can pass through the result here to skip the normalization step in this function. Make sure the colnames and rownames match the object in `x`. This matrix should correspond to one generated from this count matrix `assay(altExp(x, altExpName), i = useAssay)`. If `NA`, normalization will be carried out in the following form `normalizeCounts(assay(altExp(x, altExpName), i = useAssay),normalize = "proportion", transformationFun = sqrt)`. Use of this parameter is particularly useful for plotting many module heatmaps, where normalizing the counts matrix repeatedly would be too time consuming. Default NA.

`normalize` Character. Passed to normalizeCounts if `normalizedCounts` is `NA`. Divides counts by the library sizes for each cell. One of 'proportion', 'cpm', 'median', or 'mean'. 'proportion' uses the total counts for each cell as the library size. 'cpm' divides the library size of each cell by one million to produce counts per million. 'median' divides the library size of each cell by the median library size across all cells. 'mean' divides the library size of each cell by the mean library size across all cells. Default "proportion".

`transformationFun`
Function. Passed to normalizeCounts if `normalizedCounts` is `NA`. Applies a transformation such as sqrt, log, log2, log10, or log1p. If `NULL`, no transformation will be applied. Occurs after normalization. Default sqrt.

`scaleRow` Function. Which function to use to scale each individual row. Set to NULL to disable. Occurs after normalization and log transformation. For example, scale will Z-score transform each row. Default scale.

`showFeatureNames`
Logical. Whether feature names should be displayed. Default TRUE.

`displayName` Character. The column name of `rowData(altExp(x, altExpName))` that specifies the display names for the features. Default `NULL`, which displays the row names. Only works if `showFeaturenames` is `TRUE` and `x` is a SingleCellExperiment object.

`trim` Numeric vector. Vector of length two that specifies the lower and upper bounds for plotting the data. This threshold is applied after row scaling. Set to NULL to disable. Default `c(-2,2)`.

`rowFontSize` Numeric. Font size for feature names. If `NULL`, then the size will automatically be determined. Default `NULL`.

`showHeatmapLegend`
Passed to Heatmap. Show legend for expression levels.

`showTopAnnotationLegend`
Passed to HeatmapAnnotation. Show legend for cell annotation.

`showTopAnnotationName`
Passed to HeatmapAnnotation. Show heatmap top annotation name.

topAnnotationHeight
: Passed to HeatmapAnnotation. Column annotation height. rowAnnotation. Show legend for module annotation.

showModuleLabel
: Show left side module labels.

moduleLabel
: The left side row titles for module heatmap. Must be vector of the same length as featureModule. Default "auto", which automatically pulls module labels from x.

moduleLabelSize
: Passed to gpar. The size of text (in points).

byrow
: Passed to matrix. logical. If FALSE (the default) the figure panel is filled by columns, otherwise the figure panel is filled by rows.

top
: Passed to marrangeGrob. The title for each page.

unit
: Passed to unit. Single character object defining the unit of all dimensions defined.

ncol
: Integer. Number of columns of module heatmaps. If NULL, then this will be automatically calculated so that the number of columns and rows will be approximately the same. Default NULL.

useRaster
: Boolean. Rasterizing will make the heatmap a single object and reduced the memory of the plot and the size of a file. If NULL, then rasterization will be automatically determined by the underlying Heatmap function. Default TRUE.

returnAsList
: Boolean. If TRUE, then a list of plots will be returned instead of a single multi-panel figure. These plots can be displayed using the grid.draw function. Default FALSE.

...
: Additional parameters passed to Heatmap.

Value

A list object if plotting more than one module heatmaps. Otherwise a HeatmapList object is returned.

Examples

```
data(sceCeldaCG)
moduleHeatmap(sceCeldaCG, displayName = "rownames")
```

---

nonzero *get row and column indices of none zero elements in the matrix*

Description

get row and column indices of none zero elements in the matrix

Usage

```
nonzero(R_counts)
```

Arguments

R_counts	A matrix

Value

An integer matrix where each row is a row, column indices pair

---

normalizeCounts *Normalization of count data*

Description

Performs normalization, transformation, and/or scaling of a counts matrix

Usage

```
normalizeCounts(
  counts,
  normalize = c("proportion", "cpm", "median", "mean"),
  scaleFactor = NULL,
  transformationFun = NULL,
  scaleFun = NULL,
  pseudocountNormalize = 0,
  pseudocountTransform = 0
)
```

Arguments

counts	Integer, Numeric or Sparse matrix. Rows represent features and columns represent cells.
normalize	Character. Divides counts by the library sizes for each cell. One of 'proportion', 'cpm', 'median', or 'mean'. 'proportion' uses the total counts for each cell as the library size. 'cpm' divides the library size of each cell by one million to produce counts per million. 'median' divides the library size of each cell by the median library size across all cells. 'mean' divides the library size of each cell by the mean library size across all cells.
scaleFactor	Numeric. Sets the scale factor for cell-level normalization. This scale factor is multiplied to each cell after the library size of each cell had been adjusted in normalize. Default NULL which means no scale factor is applied.
transformationFun	Function. Applys a transformation such as sqrt, log, log2, log10, or log1p. If NULL, no transformation will be applied. Occurs after normalization. Default NULL.
scaleFun	Function. Scales the rows of the normalized and transformed count matrix. For example, 'scale' can be used to z-score normalize the rows. Default NULL.

pseudocountNormalize
: Numeric. Add a pseudocount to counts before normalization. Default 0.

pseudocountTransform
: Numeric. Add a pseudocount to normalized counts before applying the transformation function. Adding a pseudocount can be useful before applying a log transformation. Default 0.

Value

Numeric Matrix. A normalized matrix.

Examples

```
data(celdaCGSim)
normalizedCounts <- normalizeCounts(celdaCGSim$counts, "proportion",
  pseudocountNormalize = 1)
```

---

params *Get parameter values provided for celdaModel creation*

Description

Retrieves the K/L, model priors (e.g. alpha, beta), and count matrix checksum parameters provided during the creation of the provided celdaModel.

Usage

```
params(celdaMod)

## S4 method for signature 'celdaModel'
params(celdaMod)
```

Arguments

celdaMod	celdaModel. Options available in `celda::availableModels`.

Value

List. Contains the model-specific parameters for the provided celda model object depending on its class.

Examples

```
data(celdaCGMod)
params(celdaCGMod)
```

perplexity *Calculate the perplexity of a celda model*

Description

Perplexity is a statistical measure of how well a probability model can predict new data. Lower perplexity indicates a better model.

Usage

```
perplexity(
  x,
  celdaMod,
  useAssay = "counts",
  altExpName = "featureSubset",
  newCounts = NULL
)

## S4 method for signature 'SingleCellExperiment,ANY'
perplexity(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  newCounts = NULL
)

## S4 method for signature 'ANY,celda_CG'
perplexity(x, celdaMod, newCounts = NULL)

## S4 method for signature 'ANY,celda_C'
perplexity(x, celdaMod, newCounts = NULL)

## S4 method for signature 'ANY,celda_G'
perplexity(x, celdaMod, newCounts = NULL)
```

Arguments

x	Can be one of • A SingleCellExperiment object returned by celda_C, celda_G or celda_CG, with the matrix located in the useAssay assay slot. Rows represent features and columns represent cells. • Integer counts matrix. Rows represent features and columns represent cells. This matrix should be the same as the one used to generate celdaMod.
celdaMod	Celda model object. Only works if x is an integer counts matrix.
useAssay	A string specifying which assay slot to use if x is a SingleCellExperiment object. Default "counts".

altExpName	The name for the altExp slot to use. Default "featureSubset".
newCounts	A new counts matrix used to calculate perplexity. If NULL, perplexity will be calculated for the matrix in useAssay slot in x. Default NULL.

Value

Numeric. The perplexity for the provided x (and celdaModel).

Examples

```
data(sceCeldaCG)
perplexity <- perplexity(sceCeldaCG)
data(celdaCGSim, celdaCGMod)
perplexity <- perplexity(celdaCGSim$counts, celdaCGMod)
data(celdaCSim, celdaCMod)
perplexity <- perplexity(celdaCSim$counts, celdaCMod)
data(celdaGSim, celdaGMod)
perplexity <- perplexity(celdaGSim$counts, celdaGMod)
```

---

plotCeldaViolin *Feature Expression Violin Plot*

Description

Outputs a violin plot for feature expression data.

Usage

```
plotCeldaViolin(
  x,
  celdaMod,
  features,
  displayName = NULL,
  useAssay = "counts",
  altExpName = "featureSubset",
  exactMatch = TRUE,
  plotDots = TRUE,
  dotSize = 0.1
)

## S4 method for signature 'SingleCellExperiment'
plotCeldaViolin(
  x,
  features,
  displayName = NULL,
  useAssay = "counts",
  altExpName = "featureSubset",
  exactMatch = TRUE,
```

```
  plotDots = TRUE,
  dotSize = 0.1
)

## S4 method for signature 'ANY'
plotCeldaViolin(
  x,
  celdaMod,
  features,
  exactMatch = TRUE,
  plotDots = TRUE,
  dotSize = 0.1
)
```

Arguments

x	Numeric matrix or a SingleCellExperiment object with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.
celdaMod	Celda object of class "celda_G" or "celda_CG". Used only if x is a matrix object.
features	Character vector. Uses these genes for plotting.
displayName	Character. The column name of rowData(x) that specifies the display names for the features. Default NULL, which displays the row names. Only works if x is a SingleCellExperiment object.
useAssay	A string specifying which assay slot to use if x is a SingleCellExperiment object. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
exactMatch	Logical. Whether an exact match or a partial match using grep() is used to look up the feature in the rownames of the counts matrix. Default TRUE.
plotDots	Boolean. If TRUE, the expression of features will be plotted as points in addition to the violin curve. Default TRUE.
dotSize	Numeric. Size of points if plotDots = TRUE. Default 0.1.

Value

Violin plot for each feature, grouped by celda cluster

Examples

```
data(sceCeldaCG)
plotCeldaViolin(x = sceCeldaCG, features = "Gene_1")
data(celdaCGSim, celdaCGMod)
plotCeldaViolin(x = celdaCGSim$counts,
   celdaMod = celdaCGMod,
   features = "Gene_1")
```

`plotDecontXContamination` *Plots contamination on UMAP coordinates*

Description

A scatter plot of the UMAP dimensions generated by DecontX with cells colored by the estimated percentation of contamation.

Usage

```
plotDecontXContamination(
  x,
  batch = NULL,
  colorScale = c("blue", "green", "yellow", "orange", "red"),
  size = 1
)
```

Arguments

`x`	Either a SingleCellExperiment with `decontX` results stored in `metadata(x)$decontX` or the result from running decontX on a count matrix.
`batch`	Character. Batch of cells to plot. If `NULL`, then the first batch in the list will be selected. Default `NULL`.
`colorScale`	Character vector. Contains the color spectrum to be passed to `scale_colour_gradientn` from package 'ggplot2'. Default c("blue","green","yellow","orange","red").
`size`	Numeric. Size of points in the scatterplot. Default 1.

Value

Returns a `ggplot` object.

Author(s)

Shiyi Yang, Joshua Campbell

See Also

See `decontX` for a full example of how to estimate and plot contamination.

`plotDecontXMarkerExpression` *Plots expression of marker genes before and after decontamination*

Description

Generates a violin plot that shows the counts of marker genes in cells across specific clusters or cell types. Can be used to view the expression of marker genes in different cell types before and after decontamination with `decontX`.

Usage

```
plotDecontXMarkerExpression(
  x,
  markers,
  groupClusters = NULL,
  assayName = c("counts", "decontXcounts"),
  z = NULL,
  exactMatch = TRUE,
  by = "rownames",
  log1p = FALSE,
  ncol = NULL,
  plotDots = FALSE,
  dotSize = 0.1
)
```

Arguments

`x`	Either a SingleCellExperiment or a matrix-like object of counts.
`markers`	Character Vector or List. A character vector or list of character vectors with the names of the marker genes of interest.
`groupClusters`	List. A named list that allows cell clusters labels coded in `z` to be regrouped and renamed on the fly. For example, `list(Tcells=c(1, 2), Bcells=7)` would recode clusters 1 and 2 to "Tcells" and cluster 7 to "Bcells". Note that if this is used, clusters in `z` not found in `groupClusters` will be excluded. Default `NULL`.
`assayName`	Character vector. Name(s) of the assay(s) to plot if `x` is a SingleCellExperiment. If more than one assay is listed, then side-by-side violin plots will be generated. Default `c("counts", "decontXcounts")`.
`z`	Character, Integer, or Vector. Indicates the cluster labels for each cell. If `x` is a SingleCellExperiment and `z = NULL`, then the cluster labels from `decontX` will be retreived from the `colData` of `x` (i.e. `colData(x)$decontX_clusters`). If `z` is a single character or integer, then that column will be retrived from `colData` of `x`. (i.e. `colData(x)[,z]`). If `x` is a counts matrix, then `z` will need to be a vector the same length as the number of columns in `x` that indicate the cluster to which each cell belongs. Default `NULL`.

exactMatch	Boolean. Whether to only identify exact matches for the markers or to identify partial matches using grep. See retrieveFeatureIndex for more details. Default TRUE.
by	Character. Where to search for the markers if x is a SingleCellExperiment. See retrieveFeatureIndex for more details. If x is a matrix, then this must be set to "rownames". Default "rownames".
log1p	Boolean. Whether to apply the function log1p to the data before plotting. This function will add a pseudocount of 1 and then log transform the expression values. Default FALSE.
ncol	Integer. Number of columns to make in the plot. Default NULL.
plotDots	Boolean. If TRUE, the expression of features will be plotted as points in addition to the violin curve. Default FALSE.
dotSize	Numeric. Size of points if plotDots = TRUE. Default 0.1.

Value

Returns a ggplot object.

Author(s)

Shiyi Yang, Joshua Campbell

See Also

See decontX for a full example of how to estimate and plot contamination.

---

plotDecontXMarkerPercentage

Plots percentage of cells cell types expressing markers

Description

Generates a barplot that shows the percentage of cells within clusters or cell types that have detectable levels of given marker genes. Can be used to view the expression of marker genes in different cell types before and after decontamination with decontX.

Usage

```
plotDecontXMarkerPercentage(
  x,
  markers,
  groupClusters = NULL,
  assayName = c("counts", "decontXcounts"),
  z = NULL,
  threshold = 1,
  exactMatch = TRUE,
```

```
  by = "rownames",
  ncol = round(sqrt(length(markers))),
  labelBars = TRUE,
  labelSize = 3
)
```

Arguments

x	Either a SingleCellExperiment or a matrix-like object of counts.
markers	List. A named list indicating the marker genes for each cell type of interest. Multiple markers can be supplied for each cell type. For example, `list(Tcell_Markers=c("CD3E", "CD3D"),Bcell_Markers=c("CD79A", "CD79B", "MS4A1")` would specify markers for human T-cells and B-cells. A cell will be considered "positive" for a cell type if it has a count greater than `threshold` for at least one of the marker genes in the list.
groupClusters	List. A named list that allows cell clusters labels coded in `z` to be regrouped and renamed on the fly. For example, `list(Tcells=c(1, 2), Bcells=7)` would recode clusters 1 and 2 to "Tcells" and cluster 7 to "Bcells". Note that if this is used, clusters in `z` not found in `groupClusters` will be excluded from the barplot. Default `NULL`.
assayName	Character vector. Name(s) of the assay(s) to plot if `x` is a SingleCellExperiment. If more than one assay is listed, then side-by-side barplots will be generated. Default `c("counts", "decontXcounts")`.
z	Character, Integer, or Vector. Indicates the cluster labels for each cell. If `x` is a SingleCellExperiment and `z = NULL`, then the cluster labels from `decontX` will be retived from the `colData` of `x` (i.e. `colData(x)$decontX_clusters`). If `z` is a single character or integer, then that column will be retrived from `colData` of `x`. (i.e. `colData(x)[,z]`). If `x` is a counts matrix, then `z` will need to be a vector the same length as the number of columns in `x` that indicate the cluster to which each cell belongs. Default `NULL`.
threshold	Numeric. Markers greater than or equal to this value will be considered detected in a cell. Default 1.
exactMatch	Boolean. Whether to only identify exact matches for the markers or to identify partial matches using `grep`. See `retrieveFeatureIndex` for more details. Default `TRUE`.
by	Character. Where to search for the markers if `x` is a SingleCellExperiment. See `retrieveFeatureIndex` for more details. If `x` is a matrix, then this must be set to `"rownames"`.Default `"rownames"`.
ncol	Integer. Number of columns to make in the plot. Default `round(sqrt(length(markers))`.
labelBars	Boolean. Whether to display percentages above each bar Default `TRUE`.
labelSize	Numeric. Size of the percentage labels in the barplot. Default 3.

Value

Returns a `ggplot` object.

Author(s)

Shiyi Yang, Joshua Campbell

See Also

See decontX for a full example of how to estimate and plot contamination.

`plotDendro` *Plots dendrogram of* findMarkersTree *output*

Description

Generates a dendrogram of the rules and performance (optional) of the decision tree generated by findMarkersTree().

Usage

```
plotDendro(
  tree,
  classLabel = NULL,
  addSensPrec = FALSE,
  maxFeaturePrint = 4,
  leafSize = 10,
  boxSize = 2,
  boxColor = "black"
)
```

Arguments

`tree`	List object. The output of findMarkersTree()
`classLabel`	A character value. The name of a specific label to draw the path and rules. If NULL (default), the tree for all clusters is shown.
`addSensPrec`	Logical. Print training sensitivities and precisions for each cluster below leaf label? Default is FALSE.
`maxFeaturePrint`	Numeric value. Maximum number of markers to print at a given split. Default is 4.
`leafSize`	Numeric value. Size of text below each leaf. Default is 24.
`boxSize`	Numeric value. Size of rule labels. Default is 7.
`boxColor`	Character value. Color of rule labels. Default is black.

Value

A ggplot2 object

Examples

```
# Generate simulated single-cell dataset using celda
sce <- celda::simulateCells("celda_CG", K = 4, L = 10, G = 100)

# Select top features
sce <- selectFeatures(sce)

# Celda clustering into 5 clusters & 10 modules
sce <- celda_CG(sce, K=5, L=10, verbose=FALSE)

# Get features matrix and cluster assignments
factorizedCounts <- factorizeMatrix(sce, type = "counts")
featureMatrix <- factorizedCounts$counts$cell
classes <- as.integer(celdaClusters(sce))

# Generate Decision Tree
DecTree <- findMarkersTree(featureMatrix, classes)

# Plot dendrogram
plotDendro(DecTree)
```

`plotDimReduceCluster` *Plotting the cell labels on a dimension reduction plot*

Description

Create a scatterplot for each row of a normalized gene expression matrix where x and y axis are from a data dimension reduction tool. The cells are colored by "celda_cell_cluster" column in `colData(altExp(x, altExpName))` if `x` is a SingleCellExperiment object, or `x` if `x` is a integer vector of cell cluster labels.

Usage

```
plotDimReduceCluster(
  x,
  reducedDimName,
  altExpName = "featureSubset",
  dim1 = NULL,
  dim2 = NULL,
  size = 0.5,
  xlab = NULL,
  ylab = NULL,
  specificClusters = NULL,
  labelClusters = FALSE,
  groupBy = NULL,
  labelSize = 3.5
)
```

```
## S4 method for signature 'SingleCellExperiment'
plotDimReduceCluster(
  x,
  reducedDimName,
  altExpName = "featureSubset",
  dim1 = 1,
  dim2 = 2,
  size = 0.5,
  xlab = NULL,
  ylab = NULL,
  specificClusters = NULL,
  labelClusters = FALSE,
  groupBy = NULL,
  labelSize = 3.5
)

## S4 method for signature 'vector'
plotDimReduceCluster(
  x,
  dim1,
  dim2,
  size = 0.5,
  xlab = "Dimension_1",
  ylab = "Dimension_2",
  specificClusters = NULL,
  labelClusters = FALSE,
  groupBy = NULL,
  labelSize = 3.5
)
```

Arguments

x	Integer vector of cell cluster labels or a SingleCellExperiment object containing cluster labels for each cell in "celda_cell_cluster" column in colData(x).
reducedDimName	The name of the dimension reduction slot in reducedDimNames(x) if x is a SingleCellExperiment object. Ignored if both dim1 and dim2 are set.
altExpName	The name for the altExp slot to use. Default "featureSubset".
dim1	Integer or numeric vector. If reducedDimName is supplied, then, this will be used as an index to determine which dimension will be plotted on the x-axis. If reducedDimName is not supplied, then this should be a vector which will be plotted on the x-axis. Default 1.
dim2	Integer or numeric vector. If reducedDimName is supplied, then, this will be used as an index to determine which dimension will be plotted on the y-axis. If reducedDimName is not supplied, then this should be a vector which will be plotted on the y-axis. Default 2.
size	Numeric. Sets size of point on plot. Default 0.5.

xlab	Character vector. Label for the x-axis. Default NULL.
ylab	Character vector. Label for the y-axis. Default NULL.
specificClusters	Numeric vector. Only color cells in the specified clusters. All other cells will be grey. If NULL, all clusters will be colored. Default NULL.
labelClusters	Logical. Whether the cluster labels are plotted. Default FALSE.
groupBy	Character vector. Contains sample labels for each cell. If NULL, all samples will be plotted together. Default NULL.
labelSize	Numeric. Sets size of label if labelClusters is TRUE. Default 3.5.

Value

The plot as a ggplot object

Examples

```
data(sceCeldaCG)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceCluster(x = sce,
  reducedDimName = "celda_tSNE",
  specificClusters = c(1, 2, 3))
library(SingleCellExperiment)
data(sceCeldaCG, celdaCGMod)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceCluster(x = celdaClusters(celdaCGMod)$z,
  dim1 = reducedDim(altExp(sce), "celda_tSNE")[, 1],
  dim2 = reducedDim(altExp(sce), "celda_tSNE")[, 2],
  specificClusters = c(1, 2, 3))
```

---

plotDimReduceFeature *Plotting feature expression on a dimension reduction plot*

Description

Create a scatterplot for each row of a normalized gene expression matrix where x and y axis are from a data dimension reduction tool. The cells are colored by expression of the specified feature.

Usage

```
plotDimReduceFeature(
  x,
  features,
  reducedDimName = NULL,
  displayName = NULL,
  dim1 = NULL,
  dim2 = NULL,
  headers = NULL,
```

```
  useAssay = "counts",
  altExpName = "featureSubset",
  normalize = FALSE,
  zscore = TRUE,
  exactMatch = TRUE,
  trim = c(-2, 2),
  limits = c(-2, 2),
  size = 0.5,
  xlab = NULL,
  ylab = NULL,
  colorLow = "blue4",
  colorMid = "grey90",
  colorHigh = "firebrick1",
  midpoint = 0,
  ncol = NULL,
  decreasing = FALSE
)

## S4 method for signature 'SingleCellExperiment'
plotDimReduceFeature(
  x,
  features,
  reducedDimName = NULL,
  displayName = NULL,
  dim1 = 1,
  dim2 = 2,
  headers = NULL,
  useAssay = "counts",
  altExpName = "featureSubset",
  normalize = FALSE,
  zscore = TRUE,
  exactMatch = TRUE,
  trim = c(-2, 2),
  limits = c(-2, 2),
  size = 0.5,
  xlab = NULL,
  ylab = NULL,
  colorLow = "blue4",
  colorMid = "grey90",
  colorHigh = "firebrick1",
  midpoint = 0,
  ncol = NULL,
  decreasing = FALSE
)

## S4 method for signature 'ANY'
plotDimReduceFeature(
  x,
```

```
  features,
  dim1,
  dim2,
  headers = NULL,
  normalize = FALSE,
  zscore = TRUE,
  exactMatch = TRUE,
  trim = c(-2, 2),
  limits = c(-2, 2),
  size = 0.5,
  xlab = "Dimension_1",
  ylab = "Dimension_2",
  colorLow = "blue4",
  colorMid = "grey90",
  colorHigh = "firebrick1",
  midpoint = 0,
  ncol = NULL,
  decreasing = FALSE
)
```

Arguments

x	Numeric matrix or a SingleCellExperiment object with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.
features	Character vector. Features in the rownames of counts to plot.
reducedDimName	The name of the dimension reduction slot in reducedDimNames(x) if x is a SingleCellExperiment object. If NULL, then both dim1 and dim2 need to be set. Default NULL.
displayName	Character. The column name of rowData(x) that specifies the display names for the features. Default NULL, which displays the row names. Only works if x is a SingleCellExperiment object. Overwrites headers.
dim1	Integer or numeric vector. If reducedDimName is supplied, then, this will be used as an index to determine which dimension will be plotted on the x-axis. If reducedDimName is not supplied, then this should be a vector which will be plotted on the x-axis. Default 1.
dim2	Integer or numeric vector. If reducedDimName is supplied, then, this will be used as an index to determine which dimension will be plotted on the y-axis. If reducedDimName is not supplied, then this should be a vector which will be plotted on the y-axis. Default 2.
headers	Character vector. If NULL, the corresponding rownames are used as labels. Otherwise, these headers are used to label the features. Only works if displayName is NULL and exactMatch is FALSE.
useAssay	A string specifying which assay slot to use if x is a SingleCellExperiment object. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".

normalize	Logical. Whether to normalize the columns of 'counts'. Default FALSE.
zscore	Logical. Whether to scale each feature to have a mean 0 and standard deviation of 1. Default TRUE.
exactMatch	Logical. Whether an exact match or a partial match using grep() is used to look up the feature in the rownames of the counts matrix. Default TRUE.
trim	Numeric vector. Vector of length two that specifies the lower and upper bounds for the data. This threshold is applied after row scaling. Set to NULL to disable. Default c(-1,1).
limits	Passed to scale_colour_gradient2. The range of color scale.
size	Numeric. Sets size of point on plot. Default 1.
xlab	Character vector. Label for the x-axis. If reducedDimName is used, then this will be set to the column name of the first dimension of that object. Default "Dimension_1".
ylab	Character vector. Label for the y-axis. If reducedDimName is used, then this will be set to the column name of the second dimension of that object. Default "Dimension_2".
colorLow	Character. A color available from 'colors()'. The color will be used to signify the lowest values on the scale.
colorMid	Character. A color available from 'colors()'. The color will be used to signify the midpoint on the scale.
colorHigh	Character. A color available from 'colors()'. The color will be used to signify the highest values on the scale.
midpoint	Numeric. The value indicating the midpoint of the diverging color scheme. If NULL, defaults to the mean with 10 percent of values trimmed. Default 0.
ncol	Integer. Passed to facet_wrap. Specify the number of columns for facet wrap.
decreasing	logical. Specifies the order of plotting the points. If FALSE, the points will be plotted in increasing order where the points with largest values will be on top. TRUE otherwise. If NULL, no sorting is performed. Points will be plotted in their current order in x. Default FALSE.

Value

The plot as a ggplot object

Examples

```
data(sceCeldaCG)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceFeature(x = sce,
  reducedDimName = "celda_tSNE",
  normalize = TRUE,
  features = c("Gene_98", "Gene_99"),
  exactMatch = TRUE)
library(SingleCellExperiment)
data(sceCeldaCG)
sce <- celdaTsne(sceCeldaCG)
```

```
plotDimReduceFeature(x = counts(sce),
  dim1 = reducedDim(altExp(sce), "celda_tSNE")[, 1],
  dim2 = reducedDim(altExp(sce), "celda_tSNE")[, 2],
  normalize = TRUE,
  features = c("Gene_98", "Gene_99"),
  exactMatch = TRUE)
```

`plotDimReduceGrid` *Mapping the dimension reduction plot*

Description

Creates a scatterplot given two dimensions from a data dimension reduction tool (e.g tSNE) output.

Usage

```
plotDimReduceGrid(
  x,
  reducedDimName,
  dim1 = NULL,
  dim2 = NULL,
  useAssay = "counts",
  altExpName = "featureSubset",
  size = 1,
  xlab = "Dimension_1",
  ylab = "Dimension_2",
  limits = c(-2, 2),
  colorLow = "blue4",
  colorMid = "grey90",
  colorHigh = "firebrick1",
  midpoint = 0,
  varLabel = NULL,
  ncol = NULL,
  headers = NULL,
  decreasing = FALSE
)

## S4 method for signature 'SingleCellExperiment'
plotDimReduceGrid(
  x,
  reducedDimName,
  dim1 = NULL,
  dim2 = NULL,
  useAssay = "counts",
  altExpName = "featureSubset",
  size = 1,
  xlab = "Dimension_1",
```

```
  ylab = "Dimension_2",
  limits = c(-2, 2),
  colorLow = "blue4",
  colorMid = "grey90",
  colorHigh = "firebrick1",
  midpoint = 0,
  varLabel = NULL,
  ncol = NULL,
  headers = NULL,
  decreasing = FALSE
)

## S4 method for signature 'ANY'
plotDimReduceGrid(
  x,
  dim1,
  dim2,
  size = 1,
  xlab = "Dimension_1",
  ylab = "Dimension_2",
  limits = c(-2, 2),
  colorLow = "blue4",
  colorMid = "grey90",
  colorHigh = "firebrick1",
  midpoint = 0,
  varLabel = NULL,
  ncol = NULL,
  headers = NULL,
  decreasing = FALSE
)
```

Arguments

x	Numeric matrix or a SingleCellExperiment object with the matrix located in the assay slot under useAssay. Each row of the matrix will be plotted as a separate facet.
reducedDimName	The name of the dimension reduction slot in reducedDimNames(x) if x is a SingleCellExperiment object. Ignored if both dim1 and dim2 are set.
dim1	Numeric vector. Second dimension from data dimension reduction output.
dim2	Numeric vector. Second dimension from data dimension reduction output.
useAssay	A string specifying which assay slot to use if x is a SingleCellExperiment object. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
size	Numeric. Sets size of point on plot. Default 1.
xlab	Character vector. Label for the x-axis. Default 'Dimension_1'.
ylab	Character vector. Label for the y-axis. Default 'Dimension_2'.

limits	Passed to scale_colour_gradient2. The range of color scale.
colorLow	Character. A color available from 'colors()'. The color will be used to signify the lowest values on the scale. Default "blue4".
colorMid	Character. A color available from 'colors()'. The color will be used to signify the midpoint on the scale. Default "grey90".
colorHigh	Character. A color available from 'colors()'. The color will be used to signify the highest values on the scale. Default "firebrick1".
midpoint	Numeric. The value indicating the midpoint of the diverging color scheme. If NULL, defaults to the mean with 10 percent of values trimmed. Default 0.
varLabel	Character vector. Title for the color legend.
ncol	Integer. Passed to facet_wrap. Specify the number of columns for facet wrap.
headers	Character vector. If 'NULL', the corresponding rownames are used as labels. Otherwise, these headers are used to label the genes.
decreasing	logical. Specifies the order of plotting the points. If FALSE, the points will be plotted in increasing order where the points with largest values will be on top. TRUE otherwise. If NULL, no sorting is performed. Points will be plotted in their current order in x. Default FALSE.

Value

The plot as a ggplot object

Examples

```
data(sceCeldaCG)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceGrid(x = sce,
  reducedDimName = "celda_tSNE",
  xlab = "Dimension1",
  ylab = "Dimension2",
  varLabel = "tSNE")
library(SingleCellExperiment)
data(sceCeldaCG)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceGrid(x = counts(sce),
  dim1 = reducedDim(altExp(sce), "celda_tSNE")[, 1],
  dim2 = reducedDim(altExp(sce), "celda_tSNE")[, 2],
  xlab = "Dimension1",
  ylab = "Dimension2",
  varLabel = "tSNE")
```

plotDimReduceModule *Plotting Celda module probability on a dimension reduction plot*

Description

Create a scatterplot for each row of a normalized gene expression matrix where x and y axis are from a data dimension reduction tool. The cells are colored by the module probability.

Usage

```
plotDimReduceModule(
  x,
  reducedDimName,
  useAssay = "counts",
  altExpName = "featureSubset",
  celdaMod,
  modules = NULL,
  dim1 = NULL,
  dim2 = NULL,
  size = 0.5,
  xlab = NULL,
  ylab = NULL,
  rescale = TRUE,
  limits = c(0, 1),
  colorLow = "grey90",
  colorHigh = "firebrick1",
  ncol = NULL,
  decreasing = FALSE
)

## S4 method for signature 'SingleCellExperiment'
plotDimReduceModule(
  x,
  reducedDimName,
  useAssay = "counts",
  altExpName = "featureSubset",
  modules = NULL,
  dim1 = 1,
  dim2 = 2,
  size = 0.5,
  xlab = NULL,
  ylab = NULL,
  rescale = TRUE,
  limits = c(0, 1),
  colorLow = "grey90",
  colorHigh = "firebrick1",
  ncol = NULL,
```

```
  decreasing = FALSE
)

## S4 method for signature 'ANY'
plotDimReduceModule(
  x,
  celdaMod,
  modules = NULL,
  dim1,
  dim2,
  size = 0.5,
  xlab = "Dimension_1",
  ylab = "Dimension_2",
  rescale = TRUE,
  limits = c(0, 1),
  colorLow = "grey90",
  colorHigh = "firebrick1",
  ncol = NULL,
  decreasing = FALSE
)
```

Arguments

x	Numeric matrix or a SingleCellExperiment object with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.
reducedDimName	The name of the dimension reduction slot in reducedDimNames(x) if x is a SingleCellExperiment object. Ignored if both dim1 and dim2 are set.
useAssay	A string specifying which assay slot to use if x is a SingleCellExperiment object. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
celdaMod	Celda object of class "celda_G" or "celda_CG". Used only if x is a matrix object.
modules	Character vector. Module(s) from celda model to be plotted. e.g. c("1", "2").
dim1	Integer or numeric vector. If reducedDimName is supplied, then, this will be used as an index to determine which dimension will be plotted on the x-axis. If reducedDimName is not supplied, then this should be a vector which will be plotted on the x-axis. Default 1.
dim2	Integer or numeric vector. If reducedDimName is supplied, then, this will be used as an index to determine which dimension will be plotted on the y-axis. If reducedDimName is not supplied, then this should be a vector which will be plotted on the y-axis. Default 2.
size	Numeric. Sets size of point on plot. Default 0.5.
xlab	Character vector. Label for the x-axis. Default "Dimension_1".
ylab	Character vector. Label for the y-axis. Default "Dimension_2".
rescale	Logical. Whether rows of the matrix should be rescaled to [0, 1]. Default TRUE.

limits	Passed to scale_colour_gradient. The range of color scale.
colorLow	Character. A color available from 'colors()'. The color will be used to signify the lowest values on the scale.
colorHigh	Character. A color available from 'colors()'. The color will be used to signify the highest values on the scale.
ncol	Integer. Passed to facet_wrap. Specify the number of columns for facet wrap.
decreasing	logical. Specifies the order of plotting the points. If FALSE, the points will be plotted in increasing order where the points with largest values will be on top. TRUE otherwise. If NULL, no sorting is performed. Points will be plotted in their current order in x. Default FALSE.

Value

The plot as a ggplot object

Examples

```
data(sceCeldaCG)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceModule(x = sce,
  reducedDimName = "celda_tSNE",
  modules = c("1", "2"))
library(SingleCellExperiment)
data(sceCeldaCG, celdaCGMod)
sce <- celdaTsne(sceCeldaCG)
plotDimReduceModule(x = counts(sce),
  dim1 = reducedDim(altExp(sce), "celda_tSNE")[, 1],
  dim2 = reducedDim(altExp(sce), "celda_tSNE")[, 2],
  celdaMod = celdaCGMod,
  modules = c("1", "2"))
```

---

plotGridSearchPerplexity

Visualize perplexity of a list of celda models

Description

Visualize perplexity of every model in a celdaList, by unique K/L combinations

Usage

```
plotGridSearchPerplexity(x, altExpName = "featureSubset", sep = 5, alpha = 0.5)

## S4 method for signature 'SingleCellExperiment'
plotGridSearchPerplexity(x, altExpName = "featureSubset", sep = 5, alpha = 0.5)

## S4 method for signature 'celdaList'
plotGridSearchPerplexity(x, sep = 5, alpha = 0.5)
```

Arguments

x	Can be one of • A SingleCellExperiment object returned from celdaGridSearch, recursiveSplitModule, or recursiveSplitCell. Must contain a list named "celda_grid_search" in metadata(x). • celdaList object.
altExpName	The name for the altExp slot to use. Default "featureSubset". Only works if x is a SingleCellExperiment object.
sep	Numeric. Breaks in the x axis of the resulting plot.
alpha	Numeric. Passed to geom_jitter. Opacity of the points. Values of alpha range from 0 to 1, with lower values corresponding to more transparent colors.

Value

A ggplot plot object showing perplexity as a function of clustering parameters.

Examples

```
data(sceCeldaCGGridSearch)
sce <- resamplePerplexity(sceCeldaCGGridSearch)
plotGridSearchPerplexity(sce)
data(celdaCGSim, celdaCGGridSearchRes)
## Run various combinations of parameters with 'celdaGridSearch'
celdaCGGridSearchRes <- resamplePerplexity(
  celdaCGSim$counts,
  celdaCGGridSearchRes)
plotGridSearchPerplexity(celdaCGGridSearchRes)
```

---

plotHeatmap *Plots heatmap based on Celda model*

Description

Renders a heatmap based on a matrix of counts where rows are features and columns are cells.

Usage

```
plotHeatmap(
  counts,
  z = NULL,
  y = NULL,
  scaleRow = scale,
  trim = c(-2, 2),
  featureIx = NULL,
  cellIx = NULL,
  clusterFeature = TRUE,
```

```
  clusterCell = TRUE,
  colorScheme = c("divergent", "sequential"),
  colorSchemeSymmetric = TRUE,
  colorSchemeCenter = 0,
  col = NULL,
  annotationCell = NULL,
  annotationFeature = NULL,
  annotationColor = NULL,
  breaks = NULL,
  legend = TRUE,
  annotationLegend = TRUE,
  annotationNamesFeature = TRUE,
  annotationNamesCell = TRUE,
  showNamesFeature = FALSE,
  showNamesCell = FALSE,
  rowGroupOrder = NULL,
  colGroupOrder = NULL,
  hclustMethod = "ward.D2",
  treeheightFeature = ifelse(clusterFeature, 50, 0),
  treeheightCell = ifelse(clusterCell, 50, 0),
  silent = FALSE,
  ...
)
```

Arguments

counts	Numeric or sparse matrix. Normalized counts matrix where rows represent features and columns represent cells. .
z	Numeric vector. Denotes cell population labels.
y	Numeric vector. Denotes feature module labels.
scaleRow	Function. A function to scale each individual row. Set to NULL to disable. Occurs after normalization and log transformation. Defualt is 'scale' and thus will Z-score transform each row.
trim	Numeric vector. Vector of length two that specifies the lower and upper bounds for the data. This threshold is applied after row scaling. Set to NULL to disable. Default c(-2,2).
featureIx	Integer vector. Select features for display in heatmap. If NULL, no subsetting will be performed. Default NULL.
cellIx	Integer vector. Select cells for display in heatmap. If NULL, no subsetting will be performed. Default NULL.
clusterFeature	Logical. Determines whether rows should be clustered. Default TRUE.
clusterCell	Logical. Determines whether columns should be clustered. Default TRUE.
colorScheme	Character. One of "divergent" or "sequential". A "divergent" scheme is best for highlighting relative data (denoted by 'colorSchemeCenter') such as gene expression data that has been normalized and centered. A "sequential" scheme is best for highlighting data that are ordered low to high such as raw counts or probabilities. Default "divergent".

colorSchemeSymmetric
: Logical. When the colorScheme is "divergent" and the data contains both positive and negative numbers, TRUE indicates that the color scheme should be symmetric from [-max(abs(data)), max(abs(data))]. For example, if the data ranges goes from -1.5 to 2, then setting this to TRUE will force the color scheme to range from -2 to 2. Default TRUE.

colorSchemeCenter
: Numeric. Indicates the center of a "divergent" colorScheme. Default 0.

col
: Color for the heatmap.

annotationCell
: Data frame. Additional annotations for each cell will be shown in the column color bars. The format of the data frame should be one row for each cell and one column for each annotation. Numeric variables will be displayed as continuous color bars and factors will be displayed as discrete color bars. Default NULL.

annotationFeature
: A data frame for the feature annotations (rows).

annotationColor
: List. Contains color scheme for all annotations. See '?pheatmap' for more details.

breaks
: Numeric vector. A sequence of numbers that covers the range of values in the normalized 'counts'. Values in the normalized 'matrix' are assigned to each bin in 'breaks'. Each break is assigned to a unique color from 'col'. If NULL, then breaks are calculated automatically. Default NULL.

legend
: Logical. Determines whether legend should be drawn. Default TRUE.

annotationLegend
: Logical. Whether legend for all annotations should be drawn. Default TRUE.

annotationNamesFeature
: Logical. Whether the names for features should be shown. Default TRUE.

annotationNamesCell
: Logical. Whether the names for cells should be shown. Default TRUE.

showNamesFeature
: Logical. Specifies if feature names should be shown. Default TRUE.

showNamesCell
: Logical. Specifies if cell names should be shown. Default FALSE.

rowGroupOrder
: Vector. Specifies the order of feature clusters when semisupervised clustering is performed on the y labels.

colGroupOrder
: Vector. Specifies the order of cell clusters when semisupervised clustering is performed on the z labels.

hclustMethod
: Character. Specifies the method to use for the 'hclust' function. See '?hclust' for possible values. Default "ward.D2".

treeheightFeature
: Numeric. Width of the feature dendrogram. Set to 0 to disable plotting of this dendrogram. Default: if clusterFeature == TRUE, then treeheightFeature = 50, else treeheightFeature = 0.

treeheightCell
: Numeric. Height of the cell dendrogram. Set to 0 to disable plotting of this dendrogram. Default: if clusterCell == TRUE, then treeheightCell = 50, else treeheightCell = 0.

silent	Logical. Whether to plot the heatmap.
...	Other arguments to be passed to underlying pheatmap function.

Value

list A list containing dendrogram information and the heatmap grob

Examples

```
data(celdaCGSim, celdaCGMod)
plotHeatmap(celdaCGSim$counts,
  z = celdaClusters(celdaCGMod)$z, y = celdaClusters(celdaCGMod)$y
)
```

---

plotMarkerHeatmap *Generate heatmap for a marker decision tree*

Description

Creates heatmap for a specified branch point in a marker tree.

Usage

```
plotMarkerHeatmap(
  tree,
  counts,
  branchPoint,
  featureLabels,
  topFeatures = 10,
  silent = FALSE
)
```

Arguments

tree	A decision tree from CELDA's *findMarkersTree* function.
counts	Numeric matrix. Gene-by-cell counts matrix.
branchPoint	Character. Name of branch point to plot heatmap for. Name should match those in *tree$branchPoints*.
featureLabels	List of feature cluster assignments. Length should be equal to number of rows in counts matrix, and formatting should match that used in *findMarkersTree()*. Required when using clusters of features and not previously provided to *findMarkersTree()*
topFeatures	Integer. Number of genes to plot per marker module. Genes are sorted based on their AUC for their respective cluster. Default is 10.
silent	Logical. Whether to avoid plotting heatmap to screen. Default is FALSE.

Value

A heatmap visualizing the counts matrix for the cells and genes at the specified branch point.

Examples

```
sce <- celda::simulateCells("celda_CG", K = 4, L = 10, G = 100)

# Select top features
sce <- selectFeatures(sce)

# Celda clustering into 5 clusters & 10 modules
sce <- celda_CG(sce, K=5, L=10, verbose=FALSE)

# Get features matrix and cluster assignments
factorizedCounts <- factorizeMatrix(sce, type = "counts")
featureMatrix <- factorizedCounts$counts$cell
classes <- as.integer(celdaClusters(sce))

# Generate Decision Tree
DecTree <- findMarkersTree(featureMatrix, classes)

# Plot example heatmap
plotMarkerHeatmap(DecTree, featureMatrix, branchPoint = "top_level",
  featureLabels = rownames(featureMatrix))
```

---

plotRPC *Visualize perplexity differences of a list of celda models*

Description

Visualize perplexity differences of every model in a celdaList, by unique K/L combinations.

Usage

```
plotRPC(x, altExpName = "featureSubset", sep = 5, alpha = 0.5)

## S4 method for signature 'SingleCellExperiment'
plotRPC(x, altExpName = "featureSubset", sep = 5, alpha = 0.5)

## S4 method for signature 'celdaList'
plotRPC(x, sep = 5, alpha = 0.5)
```

Arguments

x	Can be one of • A SingleCellExperiment object returned from `celdaGridSearch`, `recursiveSplitModule`, or `recursiveSplitCell`. Must contain a list named `"celda_grid_search"` in `metadata(x)`.

- celdaList object.

altExpName	The name for the altExp slot to use. Default "featureSubset".
sep	Numeric. Breaks in the x axis of the resulting plot.
alpha	Numeric. Passed to geom_jitter. Opacity of the points. Values of alpha range from 0 to 1, with lower values corresponding to more transparent colors.

Value

A ggplot plot object showing perplexity differences as a function of clustering parameters.

Examples

```
data(sceCeldaCGGridSearch)
sce <- resamplePerplexity(sceCeldaCGGridSearch)
plotRPC(sce)
data(celdaCGSim, celdaCGGridSearchRes)
## Run various combinations of parameters with 'celdaGridSearch'
celdaCGGridSearchRes <- resamplePerplexity(
  celdaCGSim$counts,
  celdaCGGridSearchRes)
plotRPC(celdaCGGridSearchRes)
```

---

recodeClusterY *Recode feature module labels*

Description

Recode feature module clusters using a mapping in the `from` and `to` arguments.

Usage

```
recodeClusterY(sce, from, to, altExpName = "featureSubset")
```

Arguments

sce	SingleCellExperiment object returned from celda_G or celda_CG. Must contain column `celda_feature_module` in `rowData(altExp(sce, altExpName))`.
from	Numeric vector. Unique values in the range of `seq(celdaModules(sce))` that correspond to the original module labels in `sce`.
to	Numeric vector. Unique values in the range of `seq(celdaModules(sce))` that correspond to the new module labels.
altExpName	The name for the altExp slot to use. Default "featureSubset".

Value

@return SingleCellExperiment object with recoded feature module labels.

Examples

```
data(sceCeldaCG)
sceReorderedY <- recodeClusterY(sceCeldaCG, c(1, 3), c(3, 1))
```

`recodeClusterZ` *Recode cell cluster labels*

Description

Recode cell subpopulaton clusters using a mapping in the `from` and `to` arguments.

Usage

```
recodeClusterZ(sce, from, to, altExpName = "featureSubset")
```

Arguments

`sce`	SingleCellExperiment object returned from celda_C or celda_CG. Must contain column `celda_cell_cluster` in `colData(altExp(sce, altExpName))`.
`from`	Numeric vector. Unique values in the range of `seq(max(as.integer(celdaClusters(sce, altExpName = altExpName))))` that correspond to the original cluster labels in `sce`.
`to`	Numeric vector. Unique values in the range of `seq(max(as.integer(celdaClusters(sce, altExpName = altExpName))))` that correspond to the new cluster labels.
`altExpName`	The name for the altExp slot to use. Default "featureSubset".

Value

SingleCellExperiment object with recoded cell cluster labels.

Examples

```
data(sceCeldaCG)
sceReorderedZ <- recodeClusterZ(sceCeldaCG, c(1, 3), c(3, 1))
```

`recursiveSplitCell` *Recursive cell splitting*

Description

Uses the celda_C model to cluster cells into population for range of possible K's. The cell population labels of the previous "K-1" model are used as the initial values in the current model with K cell populations. The best split of an existing cell population is found to create the K-th cluster. This procedure is much faster than randomly initializing each model with a different K. If module labels for each feature are given in 'yInit', the celda_CG model will be used to split cell populations based on those modules instead of individual features. Module labels will also be updated during sampling and thus may end up slightly different than `yInit`.

Usage

```
recursiveSplitCell(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  initialK = 5,
  maxK = 25,
  tempL = NULL,
  yInit = NULL,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  minCell = 3,
  reorder = TRUE,
  seed = 12345,
  perplexity = TRUE,
  doResampling = FALSE,
  numResample = 5,
  logfile = NULL,
  verbose = TRUE
)

## S4 method for signature 'SingleCellExperiment'
recursiveSplitCell(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  initialK = 5,
  maxK = 25,
  tempL = NULL,
```

```
  yInit = NULL,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  minCell = 3,
  reorder = TRUE,
  seed = 12345,
  perplexity = TRUE,
  doResampling = FALSE,
  numResample = 5,
  logfile = NULL,
  verbose = TRUE
)

## S4 method for signature 'matrix'
recursiveSplitCell(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  sampleLabel = NULL,
  initialK = 5,
  maxK = 25,
  tempL = NULL,
  yInit = NULL,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  minCell = 3,
  reorder = TRUE,
  seed = 12345,
  perplexity = TRUE,
  doResampling = FALSE,
  numResample = 5,
  logfile = NULL,
  verbose = TRUE
)
```

Arguments

x	A numeric matrix of counts or a SingleCellExperiment with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.
useAssay	A string specifying the name of the assay slot to use. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
sampleLabel	Vector or factor. Denotes the sample label for each cell (column) in the count matrix.

initialK	Integer. Initial number of cell populations to try. Default 5.
maxK	Integer. Maximum number of cell populations to try. Default 25.
tempL	Integer. Number of temporary modules to identify and use in cell splitting. Only used if yInit = NULL. Collapsing features to a relatively smaller number of modules will increase the speed of clustering and tend to produce better cell populations. This number should be larger than the number of true modules expected in the dataset. Default NULL.
yInit	Integer vector. Module labels for features. Cells will be clustered using the celda_CG model based on the modules specified in yInit rather than the counts of individual features. While the features will be initialized to the module labels in yInit, the labels will be allowed to move within each new model with a different K.
alpha	Numeric. Concentration parameter for Theta. Adds a pseudocount to each cell population in each sample. Default 1.
beta	Numeric. Concentration parameter for Phi. Adds a pseudocount to each feature in each cell (if yInit is NULL) or to each module in each cell population (if yInit is set). Default 1.
delta	Numeric. Concentration parameter for Psi. Adds a pseudocount to each feature in each module. Only used if yInit is set. Default 1.
gamma	Numeric. Concentration parameter for Eta. Adds a pseudocount to the number of features in each module. Only used if yInit is set. Default 1.
minCell	Integer. Only attempt to split cell populations with at least this many cells.
reorder	Logical. Whether to reorder cell populations using hierarchical clustering after each model has been created. If FALSE, cell populations numbers will correspond to the split which created the cell populations (i.e. 'K15' was created at split 15, 'K16' was created at split 16, etc.). Default TRUE.
seed	Integer. Passed to with_seed. For reproducibility, a default value of 12345 is used. If NULL, no calls to with_seed are made.
perplexity	Logical. Whether to calculate perplexity for each model. If FALSE, then perplexity can be calculated later with resamplePerplexity. Default TRUE.
doResampling	Boolean. If TRUE, then each cell in the counts matrix will be resampled according to a multinomial distribution to introduce noise before calculating perplexity. Default FALSE.
numResample	Integer. The number of times to resample the counts matrix for evaluating perplexity if doResampling is set to TRUE. Default 5.
logfile	Character. Messages will be redirected to a file named "logfile". If NULL, messages will be printed to stdout. Default NULL.
verbose	Logical. Whether to print log messages. Default TRUE.

Value

A SingleCellExperiment object. Function parameter settings and celda model results are stored in the metadata "celda_grid_search" slot. The models in the list will be of class celda_C if yInit = NULL or celda_CG if zInit is set.

See Also

recursiveSplitModule for recursive splitting of feature modules.

Examples

```
data(sceCeldaCG)
## Create models that range from K = 3 to K = 7 by recursively splitting
## cell populations into two to produce \link{celda_C} cell clustering models
sce <- recursiveSplitCell(sceCeldaCG, initialK = 3, maxK = 7)

## Alternatively, first identify features modules using
## \link{recursiveSplitModule}
moduleSplit <- recursiveSplitModule(sceCeldaCG, initialL = 3, maxL = 15)
plotGridSearchPerplexity(moduleSplit)
moduleSplitSelect <- subsetCeldaList(moduleSplit, list(L = 10))

## Then use module labels for initialization in \link{recursiveSplitCell} to
## produce \link{celda_CG} bi-clustering models
cellSplit <- recursiveSplitCell(sceCeldaCG,
  initialK = 3, maxK = 7, yInit = celdaModules(moduleSplitSelect))
plotGridSearchPerplexity(cellSplit)
sce <- subsetCeldaList(cellSplit, list(K = 5, L = 10))
data(celdaCGSim, celdaCSim)
## Create models that range from K = 3 to K = 7 by recursively splitting
## cell populations into two to produce \link{celda_C} cell clustering models
sce <- recursiveSplitCell(celdaCSim$counts, initialK = 3, maxK = 7)

## Alternatively, first identify features modules using
## \link{recursiveSplitModule}
moduleSplit <- recursiveSplitModule(celdaCGSim$counts,
  initialL = 3, maxL = 15)
plotGridSearchPerplexity(moduleSplit)
moduleSplitSelect <- subsetCeldaList(moduleSplit, list(L = 10))

## Then use module labels for initialization in \link{recursiveSplitCell} to
## produce \link{celda_CG} bi-clustering models
cellSplit <- recursiveSplitCell(celdaCGSim$counts,
  initialK = 3, maxK = 7, yInit = celdaModules(moduleSplitSelect))
plotGridSearchPerplexity(cellSplit)
sce <- subsetCeldaList(cellSplit, list(K = 5, L = 10))
```

---

recursiveSplitModule *Recursive module splitting*

Description

Uses the celda_G model to cluster features into modules for a range of possible L's. The module labels of the previous "L-1" model are used as the initial values in the current model with L modules. The best split of an existing module is found to create the L-th module. This procedure is much faster than randomly initializing each model with a different L.

Usage

```
recursiveSplitModule(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  initialL = 10,
  maxL = 100,
  tempK = 100,
  zInit = NULL,
  sampleLabel = NULL,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  minFeature = 3,
  reorder = TRUE,
  seed = 12345,
  perplexity = TRUE,
  doResampling = FALSE,
  numResample = 5,
  verbose = TRUE,
  logfile = NULL
)

## S4 method for signature 'SingleCellExperiment'
recursiveSplitModule(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  initialL = 10,
  maxL = 100,
  tempK = 100,
  zInit = NULL,
  sampleLabel = NULL,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  minFeature = 3,
  reorder = TRUE,
  seed = 12345,
  perplexity = TRUE,
  doResampling = FALSE,
  numResample = 5,
  verbose = TRUE,
  logfile = NULL
)
```

```
## S4 method for signature 'matrix'
recursiveSplitModule(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  initialL = 10,
  maxL = 100,
  tempK = 100,
  zInit = NULL,
  sampleLabel = NULL,
  alpha = 1,
  beta = 1,
  delta = 1,
  gamma = 1,
  minFeature = 3,
  reorder = TRUE,
  seed = 12345,
  perplexity = TRUE,
  doResampling = FALSE,
  numResample = 5,
  verbose = TRUE,
  logfile = NULL
)
```

Arguments

x	A numeric matrix of counts or a SingleCellExperiment with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.
useAssay	A string specifying which assay slot to use if x is a SingleCellExperiment object. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
initialL	Integer. Initial number of modules.
maxL	Integer. Maximum number of modules.
tempK	Integer. Number of temporary cell populations to identify and use in module splitting. Only used if zInit = NULL Collapsing cells to a relatively smaller number of cell popluations will increase the speed of module clustering and tend to produce better modules. This number should be larger than the number of true cell populations expected in the dataset. Default 100.
zInit	Integer vector. Collapse cells to cell populations based on labels in zInit and then perform module splitting. If NULL, no collapsing will be performed unless tempK is specified. Default NULL.
sampleLabel	Vector or factor. Denotes the sample label for each cell (column) in the count matrix. Default NULL.
alpha	Numeric. Concentration parameter for Theta. Adds a pseudocount to each cell population in each sample. Only used if zInit is set. Default 1.

beta	Numeric. Concentration parameter for Phi. Adds a pseudocount to each feature module in each cell. Default 1.
delta	Numeric. Concentration parameter for Psi. Adds a pseudocount to each feature in each module. Default 1.
gamma	Numeric. Concentration parameter for Eta. Adds a pseudocount to the number of features in each module. Default 1.
minFeature	Integer. Only attempt to split modules with at least this many features.
reorder	Logical. Whether to reorder modules using hierarchical clustering after each model has been created. If FALSE, module numbers will correspond to the split which created the module (i.e. 'L15' was created at split 15, 'L16' was created at split 16, etc.). Default TRUE.
seed	Integer. Passed to with_seed. For reproducibility, a default value of 12345 is used. If NULL, no calls to with_seed are made.
perplexity	Logical. Whether to calculate perplexity for each model. If FALSE, then perplexity can be calculated later with resamplePerplexity. Default TRUE.
doResampling	Boolean. If TRUE, then each cell in the counts matrix will be resampled according to a multinomial distribution to introduce noise before calculating perplexity. Default FALSE.
numResample	Integer. The number of times to resample the counts matrix for evaluating perplexity if doResampling is set to TRUE. Default 5.
verbose	Logical. Whether to print log messages. Default TRUE.
logfile	Character. Messages will be redirected to a file named "logfile". If NULL, messages will be printed to stdout. Default NULL.

Value

A SingleCellExperiment object. Function parameter settings and celda model results are stored in the metadata "celda_grid_search" slot. The models in the list will be of class celda_G if zInit = NULL or celda_CG if zInit is set.

See Also

recursiveSplitCell for recursive splitting of cell populations.

Examples

```
data(sceCeldaCG)
## Create models that range from L=3 to L=20 by recursively splitting modules
## into two
moduleSplit <- recursiveSplitModule(sceCeldaCG, initialL = 3, maxL = 20)

## Example results with perplexity
plotGridSearchPerplexity(moduleSplit)

## Select model for downstream analysis
celdaMod <- subsetCeldaList(moduleSplit, list(L = 10))
data(celdaCGSim)
```

```
## Create models that range from L=3 to L=20 by recursively splitting modules
## into two
moduleSplit <- recursiveSplitModule(celdaCGSim$counts,
  initialL = 3, maxL = 20)

## Example results with perplexity
plotGridSearchPerplexity(moduleSplit)

## Select model for downstream analysis
celdaMod <- subsetCeldaList(moduleSplit, list(L = 10))
```

`reorderCelda` *Reorder cells populations and/or features modules using hierarchical clustering*

Description

Apply hierarchical clustering to reorder the cell populations and/or feature modules and group similar ones together based on the cosine distance of the factorized matrix from factorizeMatrix.

Usage

```
reorderCelda(
  x,
  celdaMod,
  useAssay = "counts",
  altExpName = "featureSubset",
  method = "complete"
)

## S4 method for signature 'SingleCellExperiment,ANY'
reorderCelda(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  method = "complete"
)

## S4 method for signature 'matrix,celda_CG'
reorderCelda(x, celdaMod, method = "complete")

## S4 method for signature 'matrix,celda_C'
reorderCelda(x, celdaMod, method = "complete")

## S4 method for signature 'matrix,celda_G'
reorderCelda(x, celdaMod, method = "complete")
```

Arguments

x	Can be one of • A SingleCellExperiment object returned by celda_C, celda_G or celda_CG, with the matrix located in the useAssay assay slot in altExp(x, altExpName). Rows represent features and columns represent cells. • Integer count matrix. Rows represent features and columns represent cells. This matrix should be the same as the one used to generate celdaMod.
celdaMod	Celda model object. Only works if x is an integer counts matrix. Ignored if x is a SingleCellExperiment object.
useAssay	A string specifying which assay slot to use if x is a SingleCellExperiment object. Default "counts".
altExpName	The name for the altExp slot. Default "featureSubset".
method	Passed to hclust. The agglomeration method to be used to be used. Default "complete".

Value

A SingleCellExperiment object (or Celda model object) with updated cell cluster and/or feature module labels.

Examples

```
data(sceCeldaCG)
reordersce <- reorderCelda(sceCeldaCG)
data(celdaCGSim, celdaCGMod)
reorderCeldaCG <- reorderCelda(celdaCGSim$counts, celdaCGMod)
data(celdaCSim, celdaCMod)
reorderCeldaC <- reorderCelda(celdaCSim$counts, celdaCMod)
data(celdaGSim, celdaGMod)
reorderCeldaG <- reorderCelda(celdaGSim$counts, celdaGMod)
```

---

reportceldaCG *Generate an HTML report for celda_CG*

Description

reportCeldaCGRun will run recursiveSplitModule and recursiveSplitCell to find the number of modules (L) and the number of cell populations (K). A final celda_CG model will be selected from recursiveSplitCell. After a celda_CG model has been fit, reportCeldaCGPlotResults can be used to create an HTML report for visualization and exploration of the celda_CG model results. Some of the plotting and feature selection functions require the installation of the Bioconductor package singleCellTK.

Usage

```
reportCeldaCGRun(
  sce,
  L,
  K,
  sampleLabel = NULL,
  altExpName = "featureSubset",
  useAssay = "counts",
  initialL = 10,
  maxL = 150,
  initialK = 5,
  maxK = 50,
  minCell = 3,
  minCount = 3,
  maxFeatures = 5000,
  output_file = "CeldaCG_RunReport",
  output_sce_prefix = "celda_cg",
  output_dir = ".",
  pdf = FALSE,
  showSession = TRUE
)

reportCeldaCGPlotResults(
  sce,
  reducedDimName,
  features = NULL,
  displayName = NULL,
  altExpName = "featureSubset",
  useAssay = "counts",
  cellAnnot = NULL,
  cellAnnotLabel = NULL,
  exactMatch = TRUE,
  moduleFilePrefix = "module_features",
  output_file = "CeldaCG_ResultReport",
  output_dir = ".",
  pdf = FALSE,
  showSetup = TRUE,
  showSession = TRUE
)
```

Arguments

sce	A SingleCellExperiment with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.
L	Integer. Final number of feature modules. See celda_CG for more information.
K	Integer. Final number of cell populations. See celda_CG for more information.
sampleLabel	Vector or factor. Denotes the sample label for each cell (column) in the count matrix.

altExpName The name for the altExp slot to use. Default "featureSubset".

useAssay A string specifying which assay slot to use. Default "counts".

initialL Integer. Minimum number of modules to try. See recursiveSplitModule for more information. Defailt 10.

maxL Integer. Maximum number of modules to try. See recursiveSplitModule for more information. Default 150.

initialK Integer. Initial number of cell populations to try.

maxK Integer. Maximum number of cell populations to try.

minCell Integer. Minimum number of cells required for feature selection. See selectFeatures for more information. Default 3.

minCount Integer. Minimum number of counts required for feature selection. See selectFeatures for more information. Default 3.

maxFeatures Integer. Maximum number of features to include. If the number of features after filtering for minCell and minCount are greater than maxFeature, then Seurat's VST function is used to select the top variable features. Default 5000.

output_file Character. Prefix of the html file. Default "CeldaCG_ResultReport".

output_sce_prefix
Character. The sce object with celda_CG results will be saved to an .rds file starting with this prefix. Default celda_cg.

output_dir Character. Path to save the html file. Default ..

pdf Boolean. Whether to create PDF versions of each plot in addition to PNGs. Default FALSE.

showSession Boolean. Whether to show the session information at the end. Default TRUE.

reducedDimName Character. Name of the reduced dimensional object to be used in 2-D scatter plots throughout the report. Default celda_UMAP.

features Character vector. Expression of these features will be displayed on a reduced dimensional plot defined by reducedDimName. If NULL, then no plotting of features on a reduced dimensinoal plot will be performed. Default NULL.

displayName Character. The name to use for display in scatter plots and heatmaps. If NULL, then the rownames of the sce object will be used. This can also be set to the name of a column in the row data of sce or altExp(sce, altExpName). Default NULL.

cellAnnot Character vector. The cell-level annotations to display on the reduced dimensional plot. These variables should be present in the column data of the sce object. Default NULL.

cellAnnotLabel Character vector. Additional cell-level annotations to display on the reduced dimensional plot. Variables will be treated as categorial and labels for each group will be placed on the plot. These variables should be present in the column data of the sce object. Default NULL.

exactMatch Boolean. Whether to only identify exact matches or to identify partial matches using grep. Default FALSE.

moduleFilePrefix
Character. The features in each module will be written to a a csv file starting with this name. If NULL, then no file will be written. Default "module_features".

showSetup Boolean. Whether to show the setup code at the beginning. Default TRUE.

Value

.html file

Examples

```
data(sceCeldaCG)
## Not run:
library(SingleCellExperiment)
sceCeldaCG$sum <- colSums(counts(sceCeldaCG))
rowData(sceCeldaCG)$rownames <- rownames(sceCeldaCG)
sceCeldaCG <- reportCeldaCGRun(sceCeldaCG,
    initialL = 5, maxL = 20, initialK = 5,
    maxK = 20, L = 10, K = 5)
reportCeldaCGPlotResults(sce = sceCeldaCG,
    reducedDimName = "celda_UMAP",
    features = c("Gene_1", "Gene_100"),
    displayName = "rownames",
    cellAnnot="sum")

## End(Not run)
```

---

resamplePerplexity *Calculate and visualize perplexity of all models in a celdaList*

Description

Calculates the perplexity of each model's cluster assignments given the provided countMatrix, as well as resamplings of that count matrix, providing a distribution of perplexities and a better sense of the quality of a given K/L choice.

Usage

```
resamplePerplexity(
  x,
  celdaList,
  useAssay = "counts",
  altExpName = "featureSubset",
  doResampling = FALSE,
  numResample = 5,
  seed = 12345
)

## S4 method for signature 'SingleCellExperiment'
resamplePerplexity(
  x,
  useAssay = "counts",
  altExpName = "featureSubset",
  doResampling = FALSE,
```

```
  numResample = 5,
  seed = 12345
)

## S4 method for signature 'ANY'
resamplePerplexity(
  x,
  celdaList,
  doResampling = FALSE,
  numResample = 5,
  seed = 12345
)
```

Arguments

x	A numeric matrix of counts or a SingleCellExperiment returned from celdaGridSearch with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells. Must contain "celda_grid_search" slot in metadata(x) if x is a SingleCellExperiment object.
celdaList	Object of class 'celdaList'. Used only if x is a matrix object.
useAssay	A string specifying which assay slot to use if x is a SingleCellExperiment object. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
doResampling	Boolean. If TRUE, then each cell in the counts matrix will be resampled according to a multinomial distribution to introduce noise before calculating perplexity. Default FALSE.
numResample	Integer. The number of times to resample the counts matrix for evaluating perplexity if doResampling is set to TRUE. Default 5.
seed	Integer. Passed to with_seed. For reproducibility, a default value of 12345 is used. If NULL, no calls to with_seed are made.

Value

A SingleCellExperiment object or celdaList object with a perplexity property, detailing the perplexity of all K/L combinations that appeared in the celdaList's models.

Examples

```
data(sceCeldaCGGridSearch)
sce <- resamplePerplexity(sceCeldaCGGridSearch)
plotGridSearchPerplexity(sce)
data(celdaCGSim, celdaCGGridSearchRes)
celdaCGGridSearchRes <- resamplePerplexity(
  celdaCGSim$counts,
  celdaCGGridSearchRes
)
plotGridSearchPerplexity(celdaCGGridSearchRes)
```

resList *Get final celdaModels from a celda model* SCE *or celdaList object*

Description

Returns all celda models generated during a celdaGridSearch run.

Usage

```
resList(x, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
resList(x, altExpName = "featureSubset")

## S4 method for signature 'celdaList'
resList(x)
```

Arguments

x	An object of class SingleCellExperiment or celdaList.
altExpName	The name for the altExp slot to use. Default "featureSubset".

Value

List. Contains one celdaModel object for each of the parameters specified in runParams(x).

Examples

```
data(sceCeldaCGGridSearch)
celdaCGGridModels <- resList(sceCeldaCGGridSearch)
data(celdaCGGridSearchRes)
celdaCGGridModels <- resList(celdaCGGridSearchRes)
```

retrieveFeatureIndex *Retrieve row index for a set of features*

Description

This will return indices of features among the rownames or rowData of a data.frame, matrix, or a SummarizedExperiment object including a SingleCellExperiment. Partial matching (i.e. grepping) can be used by setting exactMatch = FALSE.

Usage

```
retrieveFeatureIndex(
  features,
  x,
  by = "rownames",
  exactMatch = TRUE,
  removeNA = FALSE
)
```

Arguments

features	Character vector of feature names to find in the rows of x.
x	A data.frame, matrix, or SingleCellExperiment object to search.
by	Character. Where to search for features in x. If set to "rownames" then the features will be searched for among rownames(x). If x inherits from class SummarizedExperiment, then by can be one of the fields in the row annotation data.frame (i.e. one of colnames(rowData(x))).
exactMatch	Boolean. Whether to only identify exact matches or to identify partial matches using grep.
removeNA	Boolean. If set to FALSE, features not found in x will be given NA and the returned vector will be the same length as features. If set to TRUE, then the NA values will be removed from the returned vector. Default FALSE.

Value

A vector of row indices for the matching features in x.

Author(s)

Yusuke Koga, Joshua Campbell

See Also

'retrieveFeatureInfo' from package 'scater' and link{regex} for how to use regular expressions when exactMatch = FALSE.

Examples

```
data(celdaCGSim)
retrieveFeatureIndex(c("Gene_1", "Gene_5"), celdaCGSim$counts)
retrieveFeatureIndex(c("Gene_1", "Gene_5"), celdaCGSim$counts,
                                            exactMatch = FALSE)
```

runParams — *Get run parameters from a celda model* SingleCellExperiment *or* celdaList *object*

Description

Returns details on the clustering parameters and model priors from the celdaList object when it was created.

Usage

```
runParams(x, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
runParams(x, altExpName = "featureSubset")

## S4 method for signature 'celdaList'
runParams(x)
```

Arguments

x	An object of class SingleCellExperiment or class celdaList.
altExpName	The name for the altExp slot to use. Default "featureSubset".

Value

Data Frame. Contains details on the various K/L parameters, chain parameters, seed, and final log-likelihoods derived for each model in the provided celdaList.

Examples

```
data(sceCeldaCGGridSearch)
runParams(sceCeldaCGGridSearch)
data(celdaCGGridSearchRes)
runParams(celdaCGGridSearchRes)
```

sampleCells — *sampleCells*

Description

A matrix of simulated gene counts.

Usage

```
sampleCells
```

Format

A matrix of simulated gene counts with 10 rows (genes) and 10 columns (cells).

Details

A toy count matrix for use with celda.

Generated by Josh Campbell.

Source

http://github.com/campbio/celda

---

sampleLabel *Get or set sample labels from a celda SingleCellExperiment object*

Description

Return or set the sample labels for the cells in sce.

Usage

```
sampleLabel(x, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
sampleLabel(x, altExpName = "featureSubset")

sampleLabel(x, altExpName = "featureSubset") <- value

## S4 replacement method for signature 'SingleCellExperiment'
sampleLabel(x, altExpName = "featureSubset") <- value

## S4 method for signature 'celdaModel'
sampleLabel(x)
```

Arguments

x	Can be one of • A SingleCellExperiment object returned by celda_C, celda_G, or celda_CG, with the matrix located in the useAssay assay slot. Rows represent features and columns represent cells. • A celda model object.
altExpName	The name for the altExp slot to use. Default "featureSubset".
value	Character vector of sample labels for replacements. Works only is x is a SingleCellExperiment object.

Value

Character vector. Contains the sample labels provided at model creation, or those automatically generated by celda.

Examples

```
data(sceCeldaCG)
sampleLabel(sceCeldaCG)
data(celdaCGMod)
sampleLabel(celdaCGMod)
```

`sceCeldaC` *sceCeldaC*

Description

A SingleCellExperiment object containing the results of running selectFeatures and celda_C on celdaCSim.

Usage

```
sceCeldaC
```

Format

A SingleCellExperiment object

Examples

```
data(celdaCSim)
sceCeldaC <- selectFeatures(celdaCSim$counts)
sceCeldaC <- celda_C(sceCeldaC,
    K = celdaCSim$K,
    sampleLabel = celdaCSim$sampleLabel,
    nchains = 1)
```

`sceCeldaCG` *sceCeldaCG*

Description

A SingleCellExperiment object containing the results of running selectFeatures and celda_CG on celdaCGSim.

Usage

```
sceCeldaCG
```

Format

A SingleCellExperiment object

Examples

```
data(celdaCGSim)
sceCeldaCG <- selectFeatures(celdaCGSim$counts)
sceCeldaCG <- celda_CG(sceCeldaCG,
    K = celdaCGSim$K,
    L = celdaCGSim$L,
    sampleLabel = celdaCGSim$sampleLabel,
    nchains = 1)
```

---

sceCeldaCGGridSearch *sceCeldaCGGridSearch*

Description

A SingleCellExperiment object containing the results of running selectFeatures and celdaGridSearch on celdaCGSim.

Usage

```
sceCeldaCGGridSearch
```

Format

A SingleCellExperiment object

Examples

```
data(celdaCGSim)
sce <- selectFeatures(celdaCGSim$counts)
sceCeldaCGGridSearch <- celdaGridSearch(sce,
    model = "celda_CG",
    paramsTest = list(K = seq(4, 6), L = seq(9, 11)),
    paramsFixed = list(sampleLabel = celdaCGSim$sampleLabel),
    bestOnly = TRUE,
    nchains = 1,
    cores = 1,
    verbose = FALSE)
```

sceCeldaG *sceCeldaG*

Description

A SingleCellExperiment object containing the results of running selectFeatures and celda_G on celdaGSim.

Usage

```
sceCeldaG
```

Format

A SingleCellExperiment object

Examples

```
data(celdaGSim)
sceCeldaG <- selectFeatures(celdaGSim$counts)
sceCeldaG <- celda_G(sceCeldaG, L = celdaGSim$L, nchains = 1)
```

selectBestModel *Select best chain within each combination of parameters*

Description

Select the chain with the best log likelihood for each combination of tested parameters from a SCE object gererated by celdaGridSearch or from a celdaList object.

Usage

```
selectBestModel(x, asList = FALSE, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
selectBestModel(x, asList = FALSE, altExpName = "featureSubset")

## S4 method for signature 'celdaList'
selectBestModel(x, asList = FALSE)
```

Arguments

x	Can be one of • A SingleCellExperiment object returned from celdaGridSearch, recursiveSplitModule, or recursiveSplitCell. Must contain a list named "celda_grid_search" in metadata(x). • celdaList object.
asList	TRUE or FALSE. Whether to return the best model as a celdaList object or not. If FALSE, return the best model as a corresponding celda model object.
altExpName	The name for the altExp slot to use. Default "featureSubset".

Value

One of

- A new SingleCellExperiment object containing one model with the best log-likelihood for each set of parameters in metadata(x). If there is only one set of parameters, a new SingleCellExperiment object with the matching model stored in the metadata "celda_parameters" slot will be returned. Otherwise, a new SingleCellExperiment object with the subset models stored in the metadata "celda_grid_search" slot will be returned.
- A new celdaList object containing one model with the best log-likelihood for each set of parameters. If only one set of parameters is in the celdaList, the best model will be returned directly instead of a celdaList object.

See Also

celdaGridSearch subsetCeldaList

Examples

```
data(sceCeldaCGGridSearch)
## Returns same result as running celdaGridSearch with "bestOnly = TRUE"
sce <- selectBestModel(sceCeldaCGGridSearch)
data(celdaCGGridSearchRes)
## Returns same result as running celdaGridSearch with "bestOnly = TRUE"
cgsBest <- selectBestModel(celdaCGGridSearchRes)
```

---

selectFeatures *Simple feature selection by feature counts*

Description

A simple heuristic feature selection procedure. Select features with at least minCount counts in at least minCell cells. A SingleCellExperiment object with subset features will be stored in the altExp slot with name altExpName. The name of the assay slot in altExp will be the same as useAssay.

Usage

```
selectFeatures(
  x,
  minCount = 3,
  minCell = 3,
  useAssay = "counts",
  altExpName = "featureSubset"
)

## S4 method for signature 'SingleCellExperiment'
selectFeatures(
  x,
  minCount = 3,
  minCell = 3,
  useAssay = "counts",
  altExpName = "featureSubset"
)

## S4 method for signature 'matrix'
selectFeatures(
  x,
  minCount = 3,
  minCell = 3,
  useAssay = "counts",
  altExpName = "featureSubset"
)
```

Arguments

x	A numeric matrix of counts or a SingleCellExperiment with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.
minCount	Minimum number of counts required for feature selection.
minCell	Minimum number of cells required for feature selection.
useAssay	A string specifying the name of the assay slot to use. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".

Value

A SingleCellExperiment object with a altExpName altExp slot. Function parameter settings are stored in the metadata "select_features" slot.

Examples

```
data(sceCeldaCG)
sce <- selectFeatures(sceCeldaCG)
data(celdaCGSim)
sce <- selectFeatures(celdaCGSim$counts)
```

semiPheatmap *A function to draw clustered heatmaps.*

Description

A function to draw clustered heatmaps where one has better control over some graphical parameters such as cell size, etc.

The function also allows to aggregate the rows using kmeans clustering. This is advisable if number of rows is so big that R cannot handle their hierarchical clustering anymore, roughly more than 1000. Instead of showing all the rows separately one can cluster the rows in advance and show only the cluster centers. The number of clusters can be tuned with parameter kmeansK.

Usage

```
semiPheatmap(
  mat,
  color = colorRampPalette(rev(brewer.pal(n = 7, name = "RdYlBu")))(100),
  kmeansK = NA,
  breaks = NA,
  borderColor = "grey60",
  cellWidth = NA,
  cellHeight = NA,
  scale = "none",
  clusterRows = TRUE,
  clusterCols = TRUE,
  clusteringDistanceRows = "euclidean",
  clusteringDistanceCols = "euclidean",
  clusteringMethod = "complete",
  clusteringCallback = .identity2,
  cutreeRows = NA,
  cutreeCols = NA,
  treeHeightRow = ifelse(clusterRows, 50, 0),
  treeHeightCol = ifelse(clusterCols, 50, 0),
  legend = TRUE,
  legendBreaks = NA,
  legendLabels = NA,
  annotationRow = NA,
  annotationCol = NA,
  annotation = NA,
  annotationColors = NA,
  annotationLegend = TRUE,
  annotationNamesRow = TRUE,
  annotationNamesCol = TRUE,
  dropLevels = TRUE,
  showRownames = TRUE,
  showColnames = TRUE,
```

```
  main = NA,
  fontSize = 10,
  fontSizeRow = fontSize,
  fontSizeCol = fontSize,
  displayNumbers = FALSE,
  numberFormat = "%.2f",
  numberColor = "grey30",
  fontSizeNumber = 0.8 * fontSize,
  gapsRow = NULL,
  gapsCol = NULL,
  labelsRow = NULL,
  labelsCol = NULL,
  fileName = NA,
  width = NA,
  height = NA,
  silent = FALSE,
  rowLabel,
  colLabel,
  rowGroupOrder = NULL,
  colGroupOrder = NULL,
  ...
)
```

Arguments

mat	numeric matrix of the values to be plotted.
color	vector of colors used in heatmap.
kmeansK	the number of kmeans clusters to make, if we want to agggregate the rows before drawing heatmap. If NA then the rows are not aggregated.
breaks	Numeric vector. A sequence of numbers that covers the range of values in the normalized ‘counts‘. Values in the normalized ‘matrix‘ are assigned to each bin in ‘breaks‘. Each break is assigned to a unique color from ‘col‘. If NULL, then breaks are calculated automatically. Default NULL.
borderColor	color of cell borders on heatmap, use NA if no border should be drawn.
cellWidth	individual cell width in points. If left as NA, then the values depend on the size of plotting window.
cellHeight	individual cell height in points. If left as NA, then the values depend on the size of plotting window.
scale	character indicating if the values should be centered and scaled in either the row direction or the column direction, or none. Corresponding values are "row", "column" and "none".
clusterRows	boolean values determining if rows should be clustered or hclust object,
clusterCols	boolean values determining if columns should be clustered or hclust object.
clusteringDistanceRows	distance measure used in clustering rows. Possible values are "correlation" for Pearson correlation and all the distances supported by dist, such as "euclidean",

etc. If the value is none of the above it is assumed that a distance matrix is provided.

`clusteringDistanceCols`
: distance measure used in clustering columns. Possible values the same as for clusteringDistanceRows.

`clusteringMethod`
: clustering method used. Accepts the same values as `hclust`.

`clusteringCallback`
: callback function to modify the clustering. Is called with two parameters: original `hclust` object and the matrix used for clustering. Must return a `hclust` object.

`cutreeRows`
: number of clusters the rows are divided into, based on the hierarchical clustering (using cutree), if rows are not clustered, the argument is ignored

`cutreeCols`
: similar to `cutreeRows`, but for columns

`treeHeightRow`
: the height of a tree for rows, if these are clustered. Default value 50 points.

`treeHeightCol`
: the height of a tree for columns, if these are clustered. Default value 50 points.

`legend`
: logical to determine if legend should be drawn or not.

`legendBreaks`
: vector of breakpoints for the legend.

`legendLabels`
: vector of labels for the `legendBreaks`.

`annotationRow`
: data frame that specifies the annotations shown on left side of the heatmap. Each row defines the features for a specific row. The rows in the data and in the annotation are matched using corresponding row names. Note that color schemes takes into account if variable is continuous or discrete.

`annotationCol`
: similar to annotationRow, but for columns.

`annotation`
: deprecated parameter that currently sets the annotationCol if it is missing.

`annotationColors`
: list for specifying annotationRow and annotationCol track colors manually. It is possible to define the colors for only some of the features. Check examples for details.

`annotationLegend`
: boolean value showing if the legend for annotation tracks should be drawn.

`annotationNamesRow`
: boolean value showing if the names for row annotation tracks should be drawn.

`annotationNamesCol`
: boolean value showing if the names for column annotation tracks should be drawn.

`dropLevels`
: logical to determine if unused levels are also shown in the legend.

`showRownames`
: boolean specifying if column names are be shown.

`showColnames`
: boolean specifying if column names are be shown.

`main`
: the title of the plot

`fontSize`
: base fontsize for the plot

`fontSizeRow`
: fontsize for rownames (Default: fontsize)

fontSizeCol	fontsize for colnames (Default: fontsize)
displayNumbers	logical determining if the numeric values are also printed to the cells. If this is a matrix (with same dimensions as original matrix), the contents of the matrix are shown instead of original values.
numberFormat	format strings (C printf style) of the numbers shown in cells. For example "%.2f" shows 2 decimal places and "%.1e" shows exponential notation (see more in sprintf).
numberColor	color of the text
fontSizeNumber	fontsize of the numbers displayed in cells
gapsRow	vector of row indices that show shere to put gaps into heatmap. Used only if the rows are not clustered. See cutreeRow to see how to introduce gaps to clustered rows.
gapsCol	similar to gapsRow, but for columns.
labelsRow	custom labels for rows that are used instead of rownames.
labelsCol	similar to labelsRow, but for columns.
fileName	file path where to save the picture. Filetype is decided by the extension in the path. Currently following formats are supported: png, pdf, tiff, bmp, jpeg. Even if the plot does not fit into the plotting window, the file size is calculated so that the plot would fit there, unless specified otherwise.
width	manual option for determining the output file width in inches.
height	manual option for determining the output file height in inches.
silent	do not draw the plot (useful when using the gtable output)
rowLabel	row cluster labels for semi-clustering
colLabel	column cluster labels for semi-clustering
rowGroupOrder	Vector. Specifies the order of feature clusters when semisupervised clustering is performed on the y labels.
colGroupOrder	Vector. Specifies the order of cell clusters when semisupervised clustering is performed on the z labels.
...	graphical parameters for the text used in plot. Parameters passed to grid.text, see gpar.

Value

Invisibly a list of components

- treeRow the clustering of rows as hclust object
- treeCol the clustering of columns as hclust object
- kmeans the kmeans clustering of rows if parameter kmeansK was specified

Author(s)

Raivo Kolde <rkolde@gmail.com> #@examples # Create test matrix test = matrix(rnorm(200), 20, 10) test[seq(10), seq(1, 10, 2)] = test[seq(10), seq(1, 10, 2)] + 3 test[seq(11, 20), seq(2, 10, 2)] = test[seq(11, 20), seq(2, 10, 2)] + 2 test[seq(15, 20), seq(2, 10, 2)] = test[seq(15, 20), seq(2, 10, 2)] + 4 colnames(test) = paste("Test", seq(10), sep = "") rownames(test) = paste("Gene", seq(20), sep = "")

Draw heatmaps pheatmap(test) pheatmap(test, kmeansK = 2) pheatmap(test, scale = "row", clusteringDistanceRows = "correlation") pheatmap(test, color = colorRampPalette(c("navy", "white", "firebrick3"))(50)) pheatmap(test, cluster_row = FALSE) pheatmap(test, legend = FALSE)

Show text within cells pheatmap(test, displayNumbers = TRUE) pheatmap(test, displayNumbers = TRUE, numberFormat = "%.1e") pheatmap(test, displayNumbers = matrix(ifelse(test > 5, "*", ""), nrow(test))) pheatmap(test, cluster_row = FALSE, legendBreaks = seq(-1, 4), legendLabels = c("0", "1e-4", "1e-3", "1e-2", "1e-1", "1"))

Fix cell sizes and save to file with correct size pheatmap(test, cellWidth = 15, cellHeight = 12, main = "Example heatmap") pheatmap(test, cellWidth = 15, cellHeight = 12, fontSize = 8, fileName = "test.pdf")

Generate annotations for rows and columns annotationCol = data.frame(CellType = factor(rep(c("CT1", "CT2"), 5)), Time = seq(5)) rownames(annotationCol) = paste("Test", seq(10), sep = "")

annotationRow = data.frame(GeneClass = factor(rep(c("Path1", "Path2", "Path3"), c(10, 4, 6)))) rownames(annotationRow) = paste("Gene", seq(20), sep = "")

Display row and color annotations pheatmap(test, annotationCol = annotationCol) pheatmap(test, annotationCol = annotationCol, annotationLegend = FALSE) pheatmap(test, annotationCol = annotationCol, annotationRow = annotationRow)

Specify colors ann_colors = list(Time = c("white", "firebrick"), CellType = c(CT1 = "#1B9E77", CT2 = "#D95F02"), GeneClass = c(Path1 = "#7570B3", Path2 = "#E7298A", Path3 = "#66A61E"))

pheatmap(test, annotationCol = annotationCol, annotationColors = ann_colors, main = "Title") pheatmap(test, annotationCol = annotationCol, annotationRow = annotationRow, annotationColors = ann_colors) pheatmap(test, annotationCol = annotationCol, annotationColors = ann_colors[2])

Gaps in heatmaps pheatmap(test, annotationCol = annotationCol, clusterRows = FALSE, gapsRow = c(10, 14)) pheatmap(test, annotationCol = annotationCol, clusterRows = FALSE, gapsRow = c(10, 14), cutreeCol = 2)

Show custom strings as row/col names labelsRow = c("", "", "", "", "", "", "", "", "", "", "", "", "", "", "", "", "", "", "Il10", "Il15", "Il1b")

pheatmap(test, annotationCol = annotationCol, labelsRow = labelsRow)

Specifying clustering from distance matrix drows = stats::dist(test, method = "minkowski") dcols = stats::dist(t(test), method = "minkowski") pheatmap(test, clusteringDistanceRows = drows, clusteringDistanceCols = dcols)

`simulateCells` *Simulate count data from the celda generative models.*

Description

This function generates a SingleCellExperiment containing a simulated counts matrix in the `"counts"` assay slot, as well as various parameters used in the simulation which can be useful for running celda and are stored in `metadata` slot. The user must provide the desired model (one of celda_C, celda_G, celda_CG) as well as any desired tuning parameters for those model's simulation functions as detailed below.

Usage

```
simulateCells(
  model = c("celda_CG", "celda_C", "celda_G"),
  S = 5,
  CRange = c(50, 100),
  NRange = c(500, 1000),
  C = 100,
  G = 100,
  K = 5,
  L = 10,
  alpha = 1,
  beta = 1,
  gamma = 5,
  delta = 1,
  seed = 12345
)
```

Arguments

`model`	Character. Options available in `celda::availableModels`. Can be one of `"celda_CG"`, `"celda_C"`, or `"celda_G"`. Default `"celda_CG"`.
`S`	Integer. Number of samples to simulate. Default 5. Only used if `model` is one of `"celda_CG"` or `"celda_C"`.
`CRange`	Integer vector. A vector of length 2 that specifies the lower and upper bounds of the number of cells to be generated in each sample. Default c(50, 100). Only used if `model` is one of `"celda_CG"` or `"celda_C"`.
`NRange`	Integer vector. A vector of length 2 that specifies the lower and upper bounds of the number of counts generated for each cell. Default c(500, 1000).
`C`	Integer. Number of cells to simulate. Default 100. Only used if `model` is `"celda_G"`.
`G`	Integer. The total number of features to be simulated. Default 100.
`K`	Integer. Number of cell populations. Default 5. Only used if `model` is one of `"celda_CG"` or `"celda_C"`.

L	Integer. Number of feature modules. Default 10. Only used if model is one of "celda_CG" or "celda_G".
alpha	Numeric. Concentration parameter for Theta. Adds a pseudocount to each cell population in each sample. Default 1. Only used if model is one of "celda_CG" or "celda_C".
beta	Numeric. Concentration parameter for Phi. Adds a pseudocount to each feature module in each cell population. Default 1.
gamma	Numeric. Concentration parameter for Eta. Adds a pseudocount to the number of features in each module. Default 5. Only used if model is one of "celda_CG" or "celda_G".
delta	Numeric. Concentration parameter for Psi. Adds a pseudocount to each feature in each module. Default 1. Only used if model is one of "celda_CG" or "celda_G".
seed	Integer. Passed to with_seed. For reproducibility, a default value of 12345 is used. If NULL, no calls to with_seed are made.

Value

A SingleCellExperiment object with simulated count matrix stored in the "counts" assay slot. Function parameter settings are stored in the metadata slot. For "celda_CG" and "celda_C" models, columns celda_sample_label and celda_cell_cluster in colData contain simulated sample labels and cell population clusters. For "celda_CG" and "celda_G" models, column celda_feature_module in rowData contains simulated gene modules.

Examples

```
sce <- simulateCells()
```

---

simulateContamination *Simulate contaminated count matrix*

Description

This function generates a list containing two count matrices – one for real expression, the other one for contamination, as well as other parameters used in the simulation which can be useful for running decontamination.

Usage

```
simulateContamination(
  C = 300,
  G = 100,
  K = 3,
  NRange = c(500, 1000),
  beta = 0.1,
  delta = c(1, 10),
```

```
  numMarkers = 3,
  seed = 12345
)
```

Arguments

C	Integer. Number of cells to be simulated. Default 300.
G	Integer. Number of genes to be simulated. Default 100.
K	Integer. Number of cell populations to be simulated. Default 3.
NRange	Integer vector. A vector of length 2 that specifies the lower and upper bounds of the number of counts generated for each cell. Default c(500, 1000).
beta	Numeric. Concentration parameter for Phi. Default 0.1.
delta	Numeric or Numeric vector. Concentration parameter for Theta. If input as a single numeric value, symmetric values for beta distribution are specified; if input as a vector of lenght 2, the two values will be the shape1 and shape2 paramters of the beta distribution respectively. Default c(1, 5).
numMarkers	Integer. Number of markers for each cell population. Default 3.
seed	Integer. Passed to with_seed. For reproducibility, a default value of 12345 is used. If NULL, no calls to with_seed are made.

Value

A list containing the nativeMatirx (real expression), observedMatrix (real expression + contamination), as well as other parameters used in the simulation.

Author(s)

Shiyi Yang, Yuan Yin, Joshua Campbell

Examples

```
contaminationSim <- simulateContamination(K = 3, delta = c(1, 10))
```

---

splitModule *Split celda feature module*

Description

Manually select a celda feature module to split into 2 or more modules. Useful for splitting up modules that show divergent expression of features in multiple cell clusters.

Usage

```
splitModule(
  x,
  module,
  useAssay = "counts",
  altExpName = "featureSubset",
  n = 2,
  seed = 12345
)

## S4 method for signature 'SingleCellExperiment'
splitModule(
  x,
  module,
  useAssay = "counts",
  altExpName = "featureSubset",
  n = 2,
  seed = 12345
)
```

Arguments

x	A SingleCellExperiment object with the matrix located in the assay slot under useAssay. Rows represent features and columns represent cells.
module	Integer. The module to be split.
useAssay	A string specifying which assay slot to use for x. Default "counts".
altExpName	The name for the altExp slot to use. Default "featureSubset".
n	Integer. How many modules should module be split into. Default 2.
seed	Integer. Passed to with_seed. For reproducibility, a default value of 12345 is used. If NULL, no calls to with_seed are made.

Value

A updated SingleCellExperiment object with new feature modules stored in column celda_feature_module in rowData(x).

Examples

```
data(sceCeldaCG)
# Split module 5 into 2 new modules.
sce <- splitModule(sceCeldaCG, module = 5)
```

`subsetCeldaList` *Subset celda model from SCE object returned from* `celdaGridSearch`

Description

Select a subset of models from a SingleCellExperiment object generated by celdaGridSearch that match the criteria in the argument `params`.

Usage

```
subsetCeldaList(x, params, altExpName = "featureSubset")

## S4 method for signature 'SingleCellExperiment'
subsetCeldaList(x, params, altExpName = "featureSubset")

## S4 method for signature 'celdaList'
subsetCeldaList(x, params)
```

Arguments

`x`	Can be one of • A SingleCellExperiment object returned from `celdaGridSearch`, `recursiveSplitModule`, or `recursiveSplitCell`. Must contain a list named `"celda_grid_search"` in `metadata(x)`. • celdaList object.
`params`	List. List of parameters used to subset the matching celda models in list `"celda_grid_search"` in `metadata(x)`.
`altExpName`	The name for the altExp slot to use. Default "featureSubset".

Value

One of

- A new SingleCellExperiment object containing all models matching the provided criteria in `params`. If only one celda model result in the `"celda_grid_search"` slot in `metadata(x)` matches the given criteria, a new SingleCellExperiment object with the matching model stored in the metadata `"celda_parameters"` slot will be returned. Otherwise, a new SingleCellExperiment object with the subset models stored in the metadata `"celda_grid_search"` slot will be returned.
- A new `celdaList` object containing all models matching the provided criteria in `params`. If only one item in the `celdaList` matches the given criteria, the matching model will be returned directly instead of a `celdaList` object.

See Also

celdaGridSearch can run Celda with multiple parameters and chains in parallel. selectBestModel can get the best model for each combination of parameters.

Examples

```
data(sceCeldaCGGridSearch)
sceK5L10 <- subsetCeldaList(sceCeldaCGGridSearch,
    params = list(K = 5, L = 10))
data(celdaCGGridSearchRes)
resK5L10 <- subsetCeldaList(celdaCGGridSearchRes,
    params = list(K = 5, L = 10))
```

---

topRank *Identify features with the highest influence on clustering.*

Description

topRank() can quickly identify the top ‘n‘ rows for each column of a matrix. For example, this can be useful for identifying the top ‘n‘ features per cell.

Usage

```
topRank(matrix, n = 25, margin = 2, threshold = 0, decreasing = TRUE)
```

Arguments

matrix	Numeric matrix.
n	Integer. Maximum number of items above ‘threshold‘ returned for each ranked row or column.
margin	Integer. Dimension of ‘matrix‘ to rank, with 1 for rows, 2 for columns. Default 2.
threshold	Numeric. Only return ranked rows or columns in the matrix that are above this threshold. If NULL, then no threshold will be applied. Default 0.
decreasing	Logical. Specifies if the rank should be decreasing. Default TRUE.

Value

List. The ‘index‘ variable provides the top ‘n‘ row (feature) indices contributing the most to each column (cell). The ‘names‘ variable provides the rownames corresponding to these indexes.

Examples

```
data(sampleCells)
topRanksPerCell <- topRank(sampleCells, n = 5)
topFeatureNamesForCell <- topRanksPerCell$names[1]
```

Index

∗ **datasets**
availableModels, 4
celdaCGGridSearchRes, 16
celdaCGMod, 16
celdaCGSim, 16
celdaCMod, 18
celdaCSim, 18
celdaGMod, 19
celdaGSim, 22
contaminationSim, 36
sampleCells, 104
sceCeldaC, 106
sceCeldaCG, 106
sceCeldaCGGridSearch, 107
sceCeldaG, 108

altExp, *5–7*, *9*, *11–14*, *17*, *20*, *23*, *24*, *27*, *29*, *30*, *32*, *34*, *44*, *47*, *48*, *52*, *54*, *57*, *63*, *64*, *71*, *74*, *77*, *80*, *82*, *87*, *88*, *90*, *94*, *97*, *99*, *101*, *102*, *104*, *105*, *109*, *110*, *119*, *120*
appendCeldaList, 4
assay, *6*, *7*, *9*, *11*, *13*, *14*, *20*, *23*, *27*, *29*, *30*, *32*, *34*, *41*, *44*, *48*, *52*, *54*, *57*, *62*, *64*, *74*, *77*, *80*, *90*, *94*, *97*, *99*, *101*, *110*, *119*
availableModels, 4, *19*, *20*

bestLogLikelihood, 5
bestLogLikelihood,celdaModel-method *(*bestLogLikelihood*)*, 5
bestLogLikelihood,SingleCellExperiment-method *(*bestLogLikelihood*)*, 5

celda, 5
celda_C, *5*, 6, *12*, *15*, *17*, *21*, *23*, *27*, *28*, *30*, *32*, *34*, *44*, *54*, *62*, *88*, *89*, *97*, *105*, *106*
celda_C,ANY-method *(*celda_C*)*, 6
celda_C,SingleCellExperiment-method *(*celda_C*)*, 6
celda_CG, *5*, 9, *9*, *15*, *17*, *20*, *21*, *23*, *24*, *27*, *28*, *30*, *32*, *34*, *44*, *47*, *48*, *54*, *62*, *87–89*, *91*, *95*, *97*, *105*, *106*
celda_CG,ANY-method *(*celda_CG*)*, 9
celda_CG,SingleCellExperiment-method *(*celda_CG*)*, 9
celda_G, *5*, *9*, *12*, 13, *21*, *23*, *24*, *27*, *30*, *32*, *34*, *44*, *47*, *48*, *54*, *62*, *87*, *92*, *95*, *97*, *105*, *108*
celda_G,ANY-method *(*celda_G*)*, 13
celda_G,SingleCellExperiment-method *(*celda_G*)*, 13
celdaCGGridSearchRes, 16
celdaCGMod, 16
celdaCGSim, 16, *106*, *107*
celdaClusters, 17
celdaClusters,celdaModel-method *(*celdaClusters*)*, 17
celdaClusters,SingleCellExperiment-method *(*celdaClusters*)*, 17
celdaClusters<- *(*celdaClusters*)*, 17
celdaClusters<-,SingleCellExperiment-method *(*celdaClusters*)*, 17
celdaCMod, 18
celdaCSim, 18, *106*
celdaGMod, 19
celdaGridSearch, *9*, *12*, *15*, 19, *101*, *102*, *107–109*, *120*
celdaGridSearch,matrix-method *(*celdaGridSearch*)*, 19
celdaGridSearch,SingleCellExperiment-method *(*celdaGridSearch*)*, 19
celdaGSim, 22, *108*
celdaHeatmap, 22
celdaHeatmap,SingleCellExperiment-method *(*celdaHeatmap*)*, 22
celdaModel, 23

celdaModel,SingleCellExperiment-method (celdaModel), 23
celdaModules, 24
celdaModules,SingleCellExperiment-method (celdaModules), 24
celdaModules<- (celdaModules), 24
celdaModules<-,SingleCellExperiment-method (celdaModules), 24
celdaPerplexity, 25
celdaPerplexity,celdaList-method, 25
celdaProbabilityMap, 26
celdaProbabilityMap,SingleCellExperiment-method (celdaProbabilityMap), 26
celdatosce, 28
celdatosce,celda_C-method (celdatosce), 28
celdatosce,celda_CG-method (celdatosce), 28
celdatosce,celda_G-method (celdatosce), 28
celdatosce,celdaList-method (celdatosce), 28
celdaTsne, 29
celdaTsne,SingleCellExperiment-method (celdaTsne), 29
celdaUmap, 31
celdaUmap,SingleCellExperiment-method (celdaUmap), 31
clusterProbability, 34
clusterProbability,SingleCellExperiment-method (clusterProbability), 34
colData, *8*, *12*, *29*, *88*, *117*
compareCountMatrix, *29*, 35
compareCountMatrix,ANY,celdaList-method (compareCountMatrix), 35
compareCountMatrix,ANY,celdaModel-method (compareCountMatrix), 35
contaminationSim, 36
countChecksum, 36
countChecksum,celdaList-method, 37

dbscan, *38, 39*
decontX, 37, *65–69*
decontX,ANY-method (decontX), 37
decontX,SingleCellExperiment-method (decontX), 37
decontXcounts, 41
decontXcounts,SingleCellExperiment-method (decontXcounts), 41
decontXcounts<- (decontXcounts), 41
decontXcounts<-,SingleCellExperiment-method (decontXcounts), 41
dist, *112*
distinctColors, 41

eigenMatMultInt, 42
eigenMatMultNumeric, 43
enrichr, *51*

facet_wrap, *75*, *78*, *81*
factorizeMatrix, 43, *96*
factorizeMatrix,ANY,celda_C-method (factorizeMatrix), 43
factorizeMatrix,ANY,celda_CG-method (factorizeMatrix), 43
factorizeMatrix,ANY,celda_G-method (factorizeMatrix), 43
factorizeMatrix,SingleCellExperiment,ANY-method (factorizeMatrix), 43
fastNormProp, 45
fastNormPropLog, 45
fastNormPropSqrt, 46
featureModuleLookup, 46
featureModuleLookup,SingleCellExperiment-method (featureModuleLookup), 46
featureModuleTable, 48
findMarkersTree, 49
fit_dirichlet, *39*

geneSetEnrich, 51
geneSetEnrich,matrix-method (geneSetEnrich), 51
geneSetEnrich,SingleCellExperiment-method (geneSetEnrich), 51
geom_jitter, *82*, *87*
getDecisions, 53
gpar, *59*, *114*
grep, *67, 68*, *99*, *103*
grid.draw, *59*
grid.text, *114*

hclust, *97*, *113, 114*
Heatmap, *27*, *57–59*
Heatmap-class, *27*
HeatmapAnnotation, *58, 59*
HeatmapList, *27*, *59*

listEnrichrDbs, *52*

log, *58*, *60*
log10, *58*, *60*
log1p, *58*, *60*
log2, *58*, *60*
logLikelihood, 53
logLikelihood,matrix,celda_C-method (logLikelihood), 53
logLikelihood,matrix,celda_CG-method (logLikelihood), 53
logLikelihood,matrix,celda_G-method (logLikelihood), 53
logLikelihood,SingleCellExperiment,ANY-method (logLikelihood), 53
logLikelihoodHistory, 54
logLikelihoodHistory,celdaModel-method (logLikelihoodHistory), 54
logLikelihoodHistory,SingleCellExperiment-method (logLikelihoodHistory), 54

marrangeGrob, *59*
Matrix, *38*
matrix, *20*, *29*, *52*, *57*, *59*, *90*, *94*, *101*, *110*
matrixNames, 55
matrixNames,celdaModel-method (matrixNames), 55
metadata, *8*, *12*, *15*, *21*, *29*, *91*, *95*, *109*, *110*, *117*, *120*
modelGeneVar, *39*
moduleHeatmap, 56
moduleHeatmap,SingleCellExperiment-method (moduleHeatmap), 56

nonzero, 59
normalizeCounts, *31*, *33*, *58*, 60

params, 61
params,celdaModel-method (params), 61
perplexity, 62
perplexity,ANY,celda_C-method (perplexity), 62
perplexity,ANY,celda_CG-method (perplexity), 62
perplexity,ANY,celda_G-method (perplexity), 62
perplexity,SingleCellExperiment,ANY-method (perplexity), 62
plotCeldaViolin, 63
plotCeldaViolin,ANY-method (plotCeldaViolin), 63
plotCeldaViolin,SingleCellExperiment-method (plotCeldaViolin), 63
plotDecontXContamination, 65
plotDecontXMarkerExpression, 66
plotDecontXMarkerPercentage, 67
plotDendro, 69
plotDimReduceCluster, 70
plotDimReduceCluster,SingleCellExperiment-method (plotDimReduceCluster), 70
plotDimReduceCluster,vector-method (plotDimReduceCluster), 70
plotDimReduceFeature, 72
plotDimReduceFeature,ANY-method (plotDimReduceFeature), 72
plotDimReduceFeature,SingleCellExperiment-method (plotDimReduceFeature), 72
plotDimReduceGrid, 76
plotDimReduceGrid,ANY-method (plotDimReduceGrid), 76
plotDimReduceGrid,SingleCellExperiment-method (plotDimReduceGrid), 76
plotDimReduceModule, 79
plotDimReduceModule,ANY-method (plotDimReduceModule), 79
plotDimReduceModule,SingleCellExperiment-method (plotDimReduceModule), 79
plotGridSearchPerplexity, 81
plotGridSearchPerplexity,celdaList-method (plotGridSearchPerplexity), 81
plotGridSearchPerplexity,SingleCellExperiment-method (plotGridSearchPerplexity), 81
plotHeatmap, *23*, 82
plotMarkerHeatmap, 85
plotRPC, 86
plotRPC,celdaList-method (plotRPC), 86
plotRPC,SingleCellExperiment-method (plotRPC), 86

recodeClusterY, 87
recodeClusterZ, 88
recursiveSplitCell, 89, *97*
recursiveSplitCell,matrix-method (recursiveSplitCell), 89
recursiveSplitCell,SingleCellExperiment-method (recursiveSplitCell), 89
recursiveSplitModule, 92, *92*, *97*, *99*
recursiveSplitModule,matrix-method (recursiveSplitModule), 92

recursiveSplitModule,SingleCellExperiment-method (recursiveSplitModule), 92
reducedDim, *31*, *33*
reorderCelda, 96
reorderCelda,matrix,celda_C-method (reorderCelda), 96
reorderCelda,matrix,celda_CG-method (reorderCelda), 96
reorderCelda,matrix,celda_G-method (reorderCelda), 96
reorderCelda,SingleCellExperiment,ANY-method (reorderCelda), 96
reportceldaCG, 97
reportCeldaCGPlotResults (reportceldaCG), 97
reportCeldaCGRun (reportceldaCG), 97
resamplePerplexity, *21*, *91*, *95*, 100
resamplePerplexity,ANY-method (resamplePerplexity), 100
resamplePerplexity,SingleCellExperiment-method (resamplePerplexity), 100
resList, 102
resList,celdaList-method (resList), 102
resList,SingleCellExperiment-method (resList), 102
retrieveFeatureIndex, *67, 68*, 102
retrieveFeatureInfo, *103*
rowAnnotation, *59*
rowData, *12*, *15*, *29*, *87*, *117*, *119*
Rtsne, *29*
runParams, 104
runParams,celdaList-method (runParams), 104
runParams,SingleCellExperiment-method (runParams), 104

sampleCells, 104
sampleLabel, 105
sampleLabel,celdaModel-method (sampleLabel), 105
sampleLabel,SingleCellExperiment-method (sampleLabel), 105
sampleLabel<- (sampleLabel), 105
sampleLabel<-,SingleCellExperiment-method (sampleLabel), 105
scale, *58*
scale_colour_gradient, *81*
scale_colour_gradient2, *75*, *78*
sceCeldaC, 106
sceCeldaCG, 106
sceCeldaCGGridSearch, 107
sceCeldaG, 108
selectBestModel, *21*, 108, *120*
selectBestModel,celdaList-method (selectBestModel), 108
selectBestModel,SingleCellExperiment-method (selectBestModel), 108
selectFeatures, *99*, *106–108*, 109
selectFeatures,matrix-method (selectFeatures), 109
selectFeatures,SingleCellExperiment-method (selectFeatures), 109
semiPheatmap, 111
simulateCells, 116
simulateContamination, *36*, 117
SingleCellExperiment, *5–9*, *11–15*, *17*, *20, 21*, *23, 24*, *27–30*, *32*, *34*, *38–41*, *44*, *47, 48*, *51, 52*, *54*, *57, 58*, *62*, *64–68*, *70, 71*, *74*, *77*, *80*, *82*, *86–88*, *90, 91*, *94, 95*, *97, 98*, *101–110*, *116, 117*, *119, 120*
splitModule, 118
splitModule,SingleCellExperiment-method (splitModule), 118
sprintf, *114*
sqrt, *58*, *60*
subsetCeldaList, *21*, *109*, 120
subsetCeldaList,celdaList-method (subsetCeldaList), 120
subsetCeldaList,SingleCellExperiment-method (subsetCeldaList), 120
SummarizedExperiment, *102, 103*

topRank, 121

umap, *31*, *33*, *38*
unit, *59*

with_seed, *8*, *12*, *15*, *21*, *31*, *33*, *39*, *91*, *95*, *101*, *117–119*