Package ‘uSORT’

November 22, 2016

Title uSORT: A self-refining ordering pipeline for gene selection
Version 1.0.0
Author Mai Chan Lau, Hao Chen, Jinmiao Chen
Description This package is designed to uncover the intrinsic cell progression path from single-cell RNA-seq data. It incorporates data pre-processing, preliminary PCA gene selection, preliminary cell ordering, feature selection, refined cell ordering, and post-analysis interpretation and visualization.
Maintainer Hao Chen <chen_hao@immunol.a-star.edu.sg>
bioCViews RNASeq, GUI, CellBiology, DNASEq
Depends R (>= 3.3.0), tcltk
VignetteBuilder knitr
Suggests knitr, RUnit, testthat, ggplot2
Imports igraph, Matrix, RANN, RSpectra, VGAM, gplots, parallel, plyr, methods, cluster, Biobase, fpc, BiocGenerics, monocle, grDevices, graphics, stats, utils
License Artistic-2.0
Encoding UTF-8
LazyData true
RoxygenNote 5.0.1
NeedsCompilation no

R topics documented:

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autoSPIN

A wrapper function for autoSPIN sorting method

Description

A wrapper function for autoSPIN method which implements optimized local refinement using the selected SPIN sorting method, i.e. STS or Neighborhood.

Usage

autoSPIN(data, data_type = c("linear", "cyclical"),
  sorting_method = c("STS", "neighborhood"), alpha = 0.2, sigma_width = 1,
  no_randomization = 20, window_perc_range = c(0.1, 0.9),
  window_size_incre_perct = 0.05)
clusterGenes1

Arguments

data  An log2 transformed expression matrix containing n-rows of cells and m-cols of genes.
data_type  A character string indicating the type of progression, i.e. ‘linear’ (strictly linear) or ‘cyclical’ (cyclically linear).
sorting_method  A character string indicating the choice of SPIN sorting method, i.e. ‘STS’ (Side-to-Side) or ‘Neighborhood’.
alpha  A fraction value denoting the size of locality used for calculating the summed local variance.
sigma_width  An integer number denoting the degree of spread of the gaussian distribution which is used for computing weight matrix for Neighborhood sorting method.
nr_randomization  An integer number indicating the number of repeated sorting, each of which uses randomly selected initial cell position.
window_perc_range  A fraction value indicating the range of window size to be examined during local refinement.
window_size_incre_perct  A fraction value indicating the step size at each iteration for incrementing window size.

Value
A data frame containing single column of ordered sample IDs.

Examples

set.seed(15)
da <- iris[sample(150, 150, replace = FALSE), ]
rownames(da) <- paste0('spl_\',seq(1,nrow(da)))
d <- da[,1:4]
dl <- da[,5,drop=FALSE]
res <- autoSPIN(data = d)
dl <- dl[match(res$SampleID,rownames(dl)),]
annot <- data.frame(id = seq(1,nrow(res)), label=dl, stringsAsFactors = FALSE)
#ggplot(annot, aes(x=id, y=id, colour = label)) + geom_point() + theme_bw()

Description
A modified monocle’s function for ‘compareModels’ which identifies and removes genes whose reduced_models is better than full_models in term of likelihood.

Usage

clusterGenes1(expr_matrix, krange, method = function(x) { as.dist((1 - cor(t(x)))/2 ) }, ...)
Arguments

expr_matrix  Expression matrix.
krange       krange.
method       method function.
...          Other parameters.

Value

test_res a dataframe containing status of modeling and adjusted p-value

Author(s)

MaiChan Lau

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**compareModels1**  
* A modified monocle's function

Description

A modified monocle’s function for `compareModels` which identifies and removes genes whose reduced_models is better than full_models in term of likelihood

Usage

```r
compareModels1(full_models, reduced_models)
```  

Arguments

- `full_models`  a Monocle's vgam full model
- `reduced_models`  a Monocle’s vgam reduced/ null model

Value

```
test_res a dataframe containing status of modeling and adjusted p-value
```  

Author(s)

MaiChan Lau
**differentialGeneTest1**  
*differential gene test*

**Description**
modified from FludigmSC package

**Usage**
```r
differentialGeneTest1(cds,  
  fullModelFormulaStr = "expression~sm.ns(Pseudotime, df=3)",  
  reducedModelFormulaStr = "expression~1", cores = 1)
```

**Arguments**
- **cds**: Input object.
- **fullModelFormulaStr**: Full model formula.
- **reducedModelFormulaStr**: Reduced model formula.
- **cores**: Number of cores will be used.

**Value**
test results

**diff_test_helper1**  
*A modified monocle's helper function*

**Description**
A modified monocle's function for 'diff_test_helper1' which includes more attempts on finding models and also compute max. magnitude change in expression values predicted by GLM model

**Usage**
```r
diff_test_helper1(x, fullModelFormulaStr, reducedModelFormulaStr,  
  expressionFamily, lowerDetectionLimit = 0.1, type_ordering = "linear")
```

**Arguments**
- **x**: an expression data
- **fullModelFormulaStr**: a Monocle's model structure
- **reducedModelFormulaStr**: a Monocle's model structure
- **expressionFamily**: a Monocle's family character
- **lowerDetectionLimit**: a threshold value
- **type_ordering**: a character indicating the type of underlying cell progression, i.e. linear or circular
Value

test_res a dataframe containing status of modeling and adjusted p-value

Author(s)

MaiChan Lau

distance.function

A distance function computes cell-to-cell distance matrix.

Description

A distance function computes cell-to-cell distance matrix.

Usage

distance.function(expr, method = c("Euclidean", "Correlation", "eJaccard", "none"))

Arguments

expr An expression matrix containing n-rows of cells and m-cols of genes.
method A character string indicating the distance function.

Value

A matrix containing n-by-n cell distance.

driving_force_gene_selection

A feature/ gene selection function

Description

A feature/ gene selection function (1) removes sparsely expressed genes, (2) identifies differentially expressed genes based on preliminary cell ordering, (3) removes highly dispersed genes from the identified DEGs, (4) further picks genes which are expected to have large expression difference on the 2 extreme ends of preliminary cell ordering

Usage

driving_force_gene_selection(cds, scattering.cutoff.prob = 0.75, 
driving.force.cutoff = NULL, qval_cutoff = 0.05, min_expr = 0.1, 
data_type = c("linear", "cyclical"), nCores = 1)
elbow_detection

Arguments

cds a Monocle’s CellDataSet object
scattering.cutoff.prob probability used for removing largely dispersed genes
driving.force.cutoff a value used for removing genes which do not change much along cell progress along cell progress path
qval_cutoff a user-defined adjusted p-value below which genes are retained
min_expr the minimum expression value
data_type a character indicating the type of underlying cell progression, i.e. linear or cycli-cal.
nCores Number of cores to use.

Value

integer

Author(s)

MaiChan Lau

Examples

dir <- system.file('extdata', package='uSORT')
file <- list.files(dir, pattern='txt$', full=TRUE)
#exprs <- uSORT.preProcess(exprs_file = file)
#exp_raw <- t(exprs$exprs_raw)
#exp_trimmed <- t(exprs$exprs_log_trimed)
#cds <- uSORT:::EXP_to_CellDataSet(exp_trimmed, exp_raw)
#driver_genes <- driving_force_gene_selection(cds = cds)

elbow_detection A elbow detection function

Description

A elbow detection function detects the elbow/knee of a given vector of values. Values will be sorted descendingly before detection, and the ID of those values above the elbow will be returned.

Usage

elbow_detection(scores, if_plot = FALSE)

Arguments

scores A vector of numeric scores.
if_plot Boolean determine if plot the results.

Value

a vector of selected elements IDs
Examples

```r
scores <- c(10, 9, 8, 6, 3, 2, 1, 0.1)
elbow_detection(scores, if_plot = TRUE)
```

**EXP_to_CellDataSet**  
A function for constructing a Monocle's CellDataSet object from an expression matrix

Description

A function for constructing a Monocle's CellDataSet object from an expression matrix

Usage

```r
EXP_to_CellDataSet(log2_exp = NULL, expression_data_raw = NULL, lod = 1)
```

Arguments

- `log2_exp`: An log2 transformed expression matrix containing n-rows of cells and m-cols of genes.
- `expression_data_raw`: A data frame containing raw expression values, with rownames of cells and colnames of genes.
- `lod`: A value of limit of detection in the unit of TPM/CPM/RPKM.

Value

A CellDataSet object.

**fluidigmSC_analyzeGeneDetection**  
A gene detection function

Description

A gene detection function computes the fraction of genes detected in each cell, reproduced from FluidigmSC package.

Usage

```r
fluidigmSC_analyzeGeneDetection(expression_data, threshold = 1)
```

Arguments

- `expression_data`: A data frame containing raw expression values, with rownames of genes and colnames of cells.
- `threshold`: A limit of detection in the unit of TPM/CPM/RPMK.
Value

A data frame containing a column of number of genes detected, and a column of the corresponding percentage of gene detection, rownames of cells.

fluidigmSC_identifyExpOutliers

An outlier detection function

Description

An outlier detection function identifies cells with median expression below that of the bulk, reproduced from FluidigmSC package.

Usage

```r
fluidigmSC_identifyExpOutliers(log2ex_data, expression_data_raw, threshold, step, fine_step, num_fine_test, pct_goodsample_threshold = 0.5, quantile_threshold = 0.95, low_quantile_threshold = 0.25, min_gene_number = 25, lod)
```

Arguments

- `log2ex_data`: A data frame containing log2 transformed expression values, with rownames of genes and colnames of cells.
- `expression_data_raw`: A data frame containing raw expression values, with rownames of genes and colnames of cells.
- `threshold`: A value in raw expression used as the starting threshold value.
- `step`: An integer number indicating the increment of threshold value at each iteration.
- `fine_step`: An integer number indicating the increment of threshold value at each iteration, at the refining stage.
- `num_fine_test`: An integer number indicating the number of iteration of the refining stage.
- `pct_goodsample_threshold`: A fraction value indicating the minimum percentage of samples on which the representative genes are detectable.
- `quantile_threshold`: A probability of gene detection rate above which a sample is considered as good sample.
- `low_quantile_threshold`: A probability of average gene expression value below which a sample is taken as an outlier.
- `min_gene_number`: An integer indicating the minimum size of representative genes.
- `lod`: A value of limit of detection in the unit of TPM/CPM/RPKM.

Value

A vector of character stating the IDs of outlier cells.
fluidigmSC_isElementIgnoreCase

Description
A gene finding function looking for genes in the target set x from the source set y, reproduced from FluidigmSC package.

Usage
fluidigmSC_isElementIgnoreCase(x, y, ignore_case = TRUE)

Arguments
- x: A vector of characters representing gene names (target genes).
- y: A vector of characters representing gene names (source genes).
- ignore_case: Boolean, if TRUE ignores letter case.

Value
A vector of characters representing gene names.

fluidigmSC_readLinearExp

Description
An expression reading function which imports expression data from .txt file, and then computes log2 transformed data, reproduced from FluidigmSC package.

Usage
fluidigmSC_readLinearExp(exp_file = TRUE, lod = 1)

Arguments
- exp_file: Input file name in txt format, with rownames of cells and colnames of genes.
- lod: A value of limit of detection in the unit of TPM/CPM/RPKM. It will be used as the starting value for outlier cell detection and the basis for removing scarce genes.

Value
A list containing expression_data_raw(data frame), log2ex_data(data frame), and log2ex_avg_data(data frame).
**fluidigmSC_removeGenesByLinearExpForAllType**

*A gene trimming function*

**Description**

A gene trimming function removes genes whose average expression value is below the log2(threshold), and also present in at least 10

**Usage**

```r
fluidigmSC_removeGenesByLinearExpForAllType(log2ex_data, log2ex_avg_data, threshold)
```

**Arguments**

- `log2ex_data` A data frame containing log2 transformed expression values, with rownames of genes and colnames of cells.
- `log2ex_avg_data` A data frame containing log2 transformed average expression values for individual gene.
- `threshold` A limit of detection in the unit of TPM/CPM/RPMK.

**Value**

A vector of character containing gene names of those passed the filtering.

---

**fluidigmSC_removeGenesByLinearExpForAllType_log2**

*A gene trimming function*

**Description**

A gene trimming function removes genes whose average expression value is below the log2(threshold); reproduced from FluidigmSC package.

**Usage**

```r
fluidigmSC_removeGenesByLinearExpForAllType_log2(log2ex_data, threshold)
```

**Arguments**

- `log2ex_data` A data frame containing log2 tranformed expression values, with rownames of genes and colnames of cells.
- `threshold` A limit of detection in the unit of TPM/CPM/RPMK.

**Value**

A vector of character containing gene names of those passed the filtering.
### monocle_wrapper

**Description**

A wrapper function for Monocle sorting method

**Usage**

```r
monocle_wrapper(log2_exp, expression_data_raw, lod = 1)
```

**Arguments**

- `log2_exp`: An log2 transformed expression matrix containing n-rows of cells and m-cols of genes.
- `expression_data_raw`: A data frame containing raw expression values, with rownames of cells and colnames of genes.
- `lod`: A value of limit of detection in the unit of TPM/CPM/RPKM.

**Value**

A data frame containing single column of ordered sample IDs.

**Examples**

```r
set.seed(15)
da <- iris[sample(150, 150, replace = FALSE),]
rownames(da) <- paste0('spl_',seq(1,nrow(da)))
d <- da[,1:4]
dl <- da[,5,drop=FALSE]
#res <- monocle_wrapper(log2_exp = d, expression_data_raw = d)
#dl <- dl[match(res,rownames(dl)),]
#annot <- data.frame(id = seq(1,length(res)), label=dl, stringsAsFactors = FALSE)
#ggplot(annot, aes(x=id, y=id, colour = label)) + geom_point() + theme_bw()
```

### neighborhood_sorting

**Description**

A sorting function using the Neighborhood algorithm

**Usage**

```r
neighborhood_sorting(d, weights_mat = NULL, max_iter = 100)
```
**neighborhood_sortingcost**

A cost computation function for Neighborhood algorithm

### Arguments

- **d**: A matrix containing n-by-n cell distance.
- **weights_mat**: A weight matrix of size n-by-n.
- **max_iter**: An integer number indicating the maximum number of iteration if sorting does not converge.

### Value

A list containing ordering(a vector of re-ordered sequence) and cost(a numeric value).

```r
set.seed(15)
da <- iris[sample(150, 150, replace = FALSE),]
d <- da[,1:4]
randomOrdering_cost <- neighborhood_sortingcost(d, method="Euclidean")
randomOrdering_cost
da <- iris
d <- da[,1:4]
properOrdering_cost <- neighborhood_sortingcost(d, method='Euclidean')
properOrdering_cost
```
neighborhood_sorting_wrapper

* A wrapper function for Neighborhood sorting.

**Description**

A wrapper function for Neighborhood sorting as proposed in [Tsafrir et al. 2005].

**Usage**

`neighborhood_sorting_wrapper(expr, sigma_width = 1, no_randomization = 10)`

**Arguments**

- `expr`: An expression matrix containing n-rows of cells and m-cols of genes.
- `sigma_width`: An integer number determining the degree of spread of the gaussian distribution which is used for computing weight matrix for Neighborhood sorting method.
- `no_randomization`: An integer number indicating the number of repeated sorting, each of which uses a randomly selected initial cell ordering.

**Value**

A list containing `permutated.expr` (data frame) and `best.cost` (a numeric value).

---

pca_gene_selection

*Gene selection using PCA technique*

**Description**

Gene selection using PCA technique

**Usage**

`pca_gene_selection(data)`

**Arguments**

- `data`: A matrix of data.frame with row.name of cells, and col.name of genes

**Value**

A vector of the names of selected genes.

**Examples**

```r
dir <- system.file('extdata', package='uSORT')
file <- list.files(dir, pattern='.txt$', full=TRUE)
exprs <- uSORT_preProcess(exprs_file = file)
exp_trimmed <- t(exprs$exprs_log_trimed)
PCA_selected_genes <- pca_gene_selection(exp_trimmed)
```
Rwanderlust

R implementation of wanderlust

Description
R implementation of wanderlust

Usage

Rwanderlust(data, s, l = 15, k = 15, num_graphs = 1, num_waypoints = 250, waypoints_seed = 123, flock_waypoints = 2, metric = "euclidean", voting_scheme = "exponential", band_sample = FALSE, partial_order = NULL, verbose = TRUE)

Arguments

data: Input data matrix.
s: Starting point ID.
l: l nearest neighbours.
k: k nearest neighbours, k < l.
num_graphs: Number of repeated graphs.
num_waypoints: Number of waypoints to guide the trajectory detection.
waypoints_seed: The seed for reproducing the results.
flock_waypoints: The number of times for flocking the waypoints, default is 2.
metric: Distance calculation metric for nearest neighbour detection.
voting_scheme: The scheme of voting.
band_sample: Boolean, if band the sample
partial_order: default NULL
verbose: Boolean, if print the details

Value

a list containing Trajectory, Order, Waypoints

Author(s)

Hao Chen

Examples

set.seed(15)
shuffled_iris <- iris[sample(150, 150, replace = FALSE), ]
data <- shuffled_iris[,1:4]
data_label <- shuffled_iris[,5]
wishbone <- Rwanderlust(data = data, num_waypoints = 100, waypoints_seed = 2)
pd1 <- data.frame(id = wishbone$Trajectory, label=data_label, stringsAsFactors = FALSE)
pd2 <- data.frame(id = seq_along(row.names(data)), label=data_label, stringsAsFactors = FALSE)
#ggplot(pd1, aes(x=id, y=id, colour = label)) + geom_point() + theme_bw()
#ggplot(pd2, aes(x=id, y=id, colour = label)) + geom_point() + theme_bw()
scattering_quantification_per_gene
   An expression scattering measurement function

Description
   An expression scattering measurement function computes the level of scattering for individual genes
   along the cell ordering

Usage
   scattering_quantification_per_gene(CDS = NULL)

Arguments
   CDS         a Monocle’s CellDataSet object

Value
   integer

Author(s)
   MaiChan Lau

sorting_method_parameter_GUI
   GUI for sorting method parameters

Description
   The parameters appeared on GUI are based on input method, this function is called by uSORT_parameters_GUI.
   For internal use only.

Usage
   sorting_method_parameter_GUI(method = c("autoSPIN", "sWanderlust", "monocle",
                                           "Wanderlust", "SPIN", "none"))

Arguments
   method        method name.

Value
   a list of parameters.

Author(s)
   Hao Chen
**SPIN**

*A wrapper function for SPIN sorting method*

**Description**

A wrapper function for SPIN method provides a R version of SPIN [Tsafir et al. 2005].

**Usage**

```r
SPIN(data, sorting_method = c("STS", "neighborhood"), sigma_width = 1)
```

**Arguments**

- **data**: An log2 transformed expression matrix containing n-rows of cells and m-cols of genes.
- **sorting_method**: A character string indicating the choice of sorting method, i.e. 'STS' (Side-to-Side) or 'Neighborhood'.
- **sigma_width**: An integer number determining the degree of spread of the gaussian distribution which is used for computing weight matrix for Neighborhood sorting method.

**Value**

A data frame containing single column of ordered sample IDs.

**Examples**

```r
set.seed(15)
da <- iris[sample(150, 150, replace = FALSE), ]
rownames(da) <- paste0('spl_', seq(1, nrow(da))
d <- da[, 1:4]
dl <- da[, 5, drop = FALSE]
res <- SPIN(data = d)
dl <- dl[match(res$SampleID, rownames(dl)), ]
annot <- data.frame(id = seq(1, nrow(res)), label = dl, stringsAsFactors = FALSE)
#ggplot(annot, aes(x=id, y=id, colour = label)) + geom_point() + theme_bw()
```

**STS_sorting**

*A sorting function using the Side-to-Side (STS) algorithm*

**Description**

A sorting function using the Side-to-Side (STS) algorithm

**Usage**

```r
STS_sorting(d, max_iter = 10)
```
Arguments

d A matrix containing n-by-n cell distance.
max_iter An integer number indicating the maximum number of iteration if sorting does not converge.

Value

A list containing ordering(a vector of re-ordered sequence) and cost(a numeric value).

Description

A cost computation function for Side-to-Side (STS) algorithm

Usage

STS_sortingcost(expr = NULL, method = c("Euclidean", "Correlation", "eJaccard", "none"))

Arguments

eexpr An expression matrix containing n-rows of cells and m-cols of genes.
method A character string indicating the distance function.

Value

A numeric value of sorting cost.

Examples

set.seed(15)
da <- iris[sample(150, 150, replace = FALSE), ]
d <- da[,1:4]
randomOrdering_cost <- STS_sortingcost(d, method= 'Euclidean')
randomOrdering_cost
da <- iris
d <- da[,1:4]
properOrdering_cost <- STS_sortingcost(d, method= 'Euclidean')
properOrdering_cost
STS_sorting_wrapper  A wrapper function for Side-to-Side (STS) sorting.

Description
A wrapper function for Side-to-Side (STS) sorting as proposed in [Tsafrir et al. 2005].

Usage

STS_sorting_wrapper(expr, no_randomization = 10)

Arguments

expr  An expression matrix containing n-rows of cells and m-cols of genes.
no_randomization  An integer number indicating the number of repeated sorting, each of which uses a randomly selected initial cell ordering.

Value
A list containing permutated.expr (data frame) and best.cost (a numeric value).

summed_local_variance  A summed local variance function

Description
A summed local variance function

Usage

summed_local_variance(expr = NULL, alpha = NULL, data_type = "linear")

Arguments

expr  An expression matrix containing n-rows of cells and m-cols of genes.
alpha  A fraction value indicating the size of window for local variance measurement.
data_type  A character string indicating the type of progression, i.e. ‘linear’ (strictly linear) or ‘cyclical’ (cyclically linear).

Value
A numeric value of the summed local variance.
summed_local_variance_cyclical

A summed local variance function for cyclical linear data type

Description
A summed local variance function for cyclical linear data type

Usage
summed_local_variance_cyclical(d, alpha = 0.3)

Arguments
- d: A cell-to-cell distance matrix.
- alpha: A fraction value indicating the size of window for local variance measurement.

Value
A numeric value of the summed local variance.

summed_local_variance_linear

A summed local variance function for strictly linear data type

Description
A summed local variance function for strictly linear data type

Usage
summed_local_variance_linear(d, alpha = 0.3)

Arguments
- d: A cell-to-cell distance matrix.
- alpha: A fraction value indicating the size of window for local variance measurement.

Value
A numeric value of the summed local variance.
sWanderlust

Description

autoSPIN guided wanderlust. Specifically, we use autoSPIN to help find the starting point for wanderlust.

Usage

sWanderlust(data, data_type = c("linear", "cyclical"),
         SPIN_option = c("STS", "neighborhood"), alpha = 0.2, sigma_width = 1,
         diffusionmap_components = 4, l = 15, k = 15, num_waypoints = 150,
         flock_waypoints = 2, waypoints_seed = 2711)

Arguments

data data Input data matrix.
data_type The data type which guides the autoSPIN sorting, including linear, cyclical.
SPIN_option SPIN contains two options including STS (default), neighborhood.
alpha alpha parameter for autoSPIN, default is 0.2.
sigma_width Sigma width parameter for SPIN, default is 1.
diffusionmap_components Number of components from diffusion map used for wanderlust analysis, default is 4.
l Number of nearest neighbors, default is 15.
k Number of nearest neighbors for repeating graphs, default is 15, should be less than or equal to l.
num_waypoints Number of waypoint used for wanderlust, default is 150.
flock_waypoints The number of times for flocking the waypoints, default is 2.
waypoints_seed The seed for reproducing the results.

Value

a vector of the sorted order.

Author(s)

Hao Chen

Examples

set.seed(15)
shuffled_iris <- iris[sample(150, 150, replace = FALSE), ]
data <- shuffled_iris[,1:4]
data_label <- shuffled_iris[,5]
wishbone <- sWanderlust(data = data, num_waypoints = 100)
trajectory_landmarks  \textit{determining initial trajectory and landmarks}

**Description**

\textit{determining initial trajectory and landmarks}

**Usage**

\begin{verbatim}
trajectory_landmarks(knn, data, s, partial_order = NULL, waypoints = 250, 
waypoints_seed = 123, metric = "euclidean", flock_waypoints = 2, 
band_sample = FALSE)
\end{verbatim}

**Arguments**

\begin{itemize}
\item \texttt{knn} \hspace{1cm} A sparse matrix of knn.
\item \texttt{data} \hspace{1cm} data.
\item \texttt{s} \hspace{1cm} The ID of starting point.
\item \texttt{partial_order} \hspace{1cm} A vector of IDs specified as recommended waypoints, NULL to ignore.
\item \texttt{waypoints} \hspace{1cm} Either the number of waypoints, or specify the waypoint IDs.
\item \texttt{waypoints_seed} \hspace{1cm} Random sampling seed, for reproducible results.
\item \texttt{metric} \hspace{1cm} Distance calculation metric for nearest neighbour detection.
\item \texttt{flock_waypoints} \hspace{1cm} Iteration of using nearest points around waypoint to adjust its position.
\item \texttt{band_sample} \hspace{1cm} if give more chance to nearest neighbours of starting point in randomly waypoints selection.
\end{itemize}

**Value**

\texttt{a list}

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\textit{uSORT}

\textit{uSORT: A self-refining ordering pipeline for gene selection}

**Description**

This package is designed to uncover the intrinsic cell progression path from single-cell RNA-seq data.

The main function of \texttt{uSORT}\texttt{-package} which provides a workflow of sorting scRNA-seq data.
Usage

uSORT(exprs_file, log_transform = TRUE, remove_outliers = TRUE, preliminary_sorting_method = c("autoSPIN", "sWanderlust", "monocle", "Wanderlust", "SPIN", "none"), refine_sorting_method = c("autoSPIN", "sWanderlust", "monocle", "Wanderlust", "SPIN", "none"), project_name = "uSORT", result_directory = getwd(), nCores = 1, save_results = TRUE, reproduce_seed = 1234, scattering_cutoff_prob = 0.75, driving_force_cutoff = NULL, qval_cutoff_featureSelection = 0.05, pre_data_type = c("linear", "cyclical"), pre_SPIN_option = c("STS", "neighborhood"), pre_autoSPIN_sigma_width = 1, pre_autoSPIN_randomization = 20, pre_wanderlust_start_cell = NULL, pre_wanderlust_dfmap_components = 4, pre_wanderlust_num_waypoints = 150, pre_wanderlust_dfmap_components = 4, pre_wanderlust_l = 15, pre_wanderlust_num_waypoints = 150, pre_wanderlust_num_waypoints = 150, pre_wanderlust_flock_waypoints = 2, ref_data_type = c("linear", "cyclical"), ref_SPIN_option = c("STS", "neighborhood"), ref_SPIN_sigma_width = 1, ref_autoSPIN_randomization = 20, ref_wanderlust_dfmap_components = 4, ref_wanderlust_num_waypoints = 150, ref_wanderlust_dfmap_components = 4, ref_wanderlust_l = 15, ref_wanderlust_num_waypoints = 150, ref_wanderlust_flock_waypoints = 2, ref_wanderlust_flock_waypoints = 2)

Arguments

eexprs_file: Input file name in txt format, with rownames of cells and colnames of genes.

log_transform: Boolean, if log transform the data.

remove_outliers: Boolean, if remove the outliers.

preliminary_sorting_method: Method name for preliminary sorting, including autoSPIN, sWanderlust, monocle, Wanderlust, SPIN, or none.

refine_sorting_method: Method name for refined sorting, including autoSPIN, sWanderlust, monocle, Wanderlust, SPIN, or none.

project_name: A character name as the prefix of the saved result file.

result_directory: The directory indicating where to save the results.

nCores: Number of cores that will be employed for drive gene selection (parallel computing), default is 1.

save_results: Boolean determining if save the results.

reproduce_seed: A seed used for reproducing the result.

scattering_cutoff_prob: Scattering cutoff value probability for gene selection, default 0.75.

driving_force_cutoff: Driving force cutoff value for gene selection, default NULL(automatically).

qval_cutoff_featureSelection: Q value cutoff for gene selection, default 0.05.

pre_data_type: The data type which guides the autoSPIN sorting, including linear, cyclical.
pre_SPIN_option
  SPIN contains two options including STS (default), neighborhood.
pre_SPIN_sigma_width
  Sigma width parameter for SPIN, default is 1.
pre_autoSPIN_alpha
  alpha parameter for autoSPIN, default is 0.2.
pre_autoSPIN_randomization
  Number of randomizations for autoSPIN, default is 20.
pre_wanderlust_start_cell
  The name of starting cell for wanderlust, default is the first cell from the data.
pre_wanderlust_dmap_components
  Number of components from diffusion map used for wanderlust analysis, default is 4.
pre_wanderlust_l
  Number of nearest neighbors used for wanderlust, default is 15.
pre_wanderlust_num_waypoints
  Number of waypoint used for wanderlust, default is 150.
pre_wanderlust_waypoints_seed
  The seed for reproducing the wanderlust results.
pre_wanderlust_flock_waypoints
  The number of times for flocking the waypoints, default is 2.
ref_data_type
  The data type which guides the autoSPIN sorting, including linear, cyclical.
ref_SPIN_option
  SPIN contains two options including STS (default), neighborhood.
ref_SPIN_sigma_width
  Sigma width parameter for SPIN, default is 1.
ref_autoSPIN_alpha
  alpha parameter for autoSPIN, default is 0.2.
ref_autoSPIN_randomization
  Number of randomizations for autoSPIN, default is 20.
ref_wanderlust_start_cell
  The name of starting cell for wanderlust, default is the first cell from the data.
ref_wanderlust_dmap_components
  Number of components from diffusion map used for wanderlust analysis, default is 4.
ref_wanderlust_l
  Number of nearest neighbors used for wanderlust, default is 15.
ref_wanderlust_num_waypoints
  Number of waypoint used for wanderlust, default is 150.
ref_wanderlust_flock_waypoints
  The number of times for flocking the waypoints, default is 2.
ref_wanderlust_waypoints_seed
  The seed for reproducing the wanderlust results.

Details

This package incorporates data pre-processing, preliminary PCA gene selection, preliminary cell ordering, feature selection, refined cell ordering, and post-analysis interpretation and visualization. The uSORT workflow can be implemented through calling the main function or the GUI. uSORT.
The user friendly GUI for uSORT-package

Description

This GUI provides an easy way for applying the uSORT package.

Usage

uSORT_GUI()

Value

the GUI for uSORT-package

Author(s)

Hao Chen

References

http://JinmiaoChenLab.github.io/uSORT/

See Also

uSORT-package, uSORT

Examples

interactive()
#if(interactive()) uSORT_GUI()  # remove the hash symbol to run
uSORT_parameters_GUI  The GUI for inputting parameters for uSORT

Description
This is a function for generating the GUI for uSORT, it’s called by uSORT_GUI. For internal use only.

Usage
uSORT_parameters_GUI()

Value
a list of parameters.

Author(s)
Hao Chen

uSORT_preProcess  A data loading and pre-processing function

Description
A data loading and pre-processing function which firstly identifies outlier cells and scarcely expressed genes.

Usage
uSORT_preProcess(exprs_file, log_transform = TRUE, remove_outliers = TRUE, lod = 1)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exprs_file</td>
<td>Input file name in txt format, with rownames of cells and colnames of genes.</td>
</tr>
<tr>
<td>log_transform</td>
<td>Boolean, if TRUE log transform the data.</td>
</tr>
<tr>
<td>remove_outliers</td>
<td>Boolean, if TRUE remove the outliers.</td>
</tr>
<tr>
<td>lod</td>
<td>A value of limit of detection in the unit of TPM/CPM/RPKM. It will be used</td>
</tr>
<tr>
<td></td>
<td>as the starting value for outlier cell detection and the basis for removing</td>
</tr>
<tr>
<td></td>
<td>scarce genes.</td>
</tr>
</tbody>
</table>

Value
A list containing exprs_raw(data frame) and exprs_log_trimed(data.frame).

Examples

```r
dir <- system.file('extdata', package='uSORT')
file <- list.files(dir, pattern='.txt$', full=TRUE)
exprs <- uSORT_preProcess(exprs_file = file)
```
**uSORT_sorting_wrapper**  
wrapper of all available sorting methods in **uSORT**

**Description**

Sorting methods include **autoSPIN**, **sWanderlust**, **monocle**, **Wanderlust**, **SPIN**. Any of the sorting method can be called directly using this function.

**Usage**

```r
uSORT_sorting_wrapper(data, data_raw, method = c("autoSPIN", "sWanderlust", "monocle", "Wanderlust", "SPIN", "none"),
                      data_type = c("linear", "cyclical"),
                      SPIN_option = c("STS", "neighborhood"),
                      SPIN_sigma_width = 1,
                      autoSPIN_alpha = 0.2, autoSPIN_randomization = 20,
                      wanderlust_start_cell = NULL, wanderlust_dfmap_components = 4,
                      wanderlust_l = 15, wanderlust_num_waypoints = 150,
                      wanderlust_waypoints_seed = 2711, wanderlust_flock_waypoints = 2)
```

**Arguments**

- `data`  
  Input preprocessed data matrix with row.name of cells and col.name of genes.
- `data_raw`  
  Input raw data matrix with row.name of cells and col.name of genes, for monocle method.
- `method`  
  The name of the sorting method to use, including **autoSPIN**, **sWanderlust**, **monocle**, **Wanderlust**, **SPIN** and **none**.
- `data_type`  
  The type of the data, either **linear** or **cyclical**.
- `SPIN_option`  
  The running option of SPIN, **STS** or **neighborhood**.
- `SPIN_sigma_width`  
  Sigma width for SPIN.
- `autoSPIN_alpha`  
  Alpha for autoSPIN.
- `autoSPIN_randomization`  
  Number of randomization for autoSPIN.
- `wanderlust_start_cell`  
  The id of the starting cell for wanderlust.
- `wanderlust_dfmap_components`  
  The number of components from diffusionmap for wanderlust.
- `wanderlust_l`  
  The number of nearest neighbors used for wanderlust.
- `wanderlust_num_waypoints`  
  The number of waypoints for wanderlust.
- `wanderlust_waypoints_seed`  
  The seed for reproducible analysis.
- `wanderlust_flock_waypoints`  
  The number of flock times for wanderlust.

**Value**

return the order of sorting results.
Examples

```r
dir <- system.file('extdata', package='uSORT')
file <- list.files(dir, pattern='.txt$', full=TRUE)
exprs <- uSORT_preProcess(exprs_file = file)
exp(trimmed) <- t(exprs$log.trimmed)
PCA.selected.genes <- pca.gene.selection(exp.trimmed)
exp.PCA.genes <- exp.trimmed[, PCA.selected.genes]
#order <- uSORT_sorting_wrapper(data = exp.PCA.genes, method = 'autoSPIN')
```

uSORT_write_results

```
Results parsing for uSORT
```

Description

Save result object into a RData file. Save cell to cell distance heatmap for both preliminary and refined results. Create plot of driver gene profiles on final ordering using heatmap.

Usage

```r
uSORT_write_results(uSORT_results, project_name, result_directory)
```

Arguments

- `uSORT_results`: Result object from `uSort` function, a list.
- `project_name`: A prefix for the saving files.
- `result_directory`: The path where to save the results.

Value

save the results.

Examples

```r
dir <- system.file('extdata', package='uSORT')
file <- list.files(dir, pattern='.txt$', full=TRUE)
#remove the # symbol of the following codes to test
#uSORT_results <- uSORT(exprs_file = file,
# project_name = 'test',
# preliminary_sorting_method = 'autoSPIN',
# refine_sorting_method = 'sWanderlust',
# save_results = FALSE)
#uSORT_write_results(uSORT_results,
# project_name = 'test',
# result_directory = getwd())
```
**variability_per_gene**

A utility function for scattering_quantification_per_gene.

**Description**

A utility function for scattering_quantification_per_gene which computes the degree of scattering for single gene, whereby the value is computed by summing over the local values of smaller local windows.

**Usage**

```r
variability_per_gene(logExp = NULL, min_expr = 0.1, window_size_perct = 0.1, nonZeroExpr_perct = 0.1)
```

**Arguments**

- `min_expr`: a minimum expression value.
- `window_size_perct`: a window size (in dispersion level).
- `nonZeroExpr_perct`: a minimum amount of cells (in expression, otherwise the associated window will be assigned to 0 disperson value).

**Value**

integer.

**Author(s)**

MaiChan Lau.

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**wanderlust_wrapper**

A wrapper of wanderlust for sWanderlust.

**Description**

A wrapper of wanderlust for sWanderlust.

**Usage**

```r
wanderlust_wrapper(data, s, diffusionmap_components = 4, l = 15, k = 15, num_graphs = 1, num_waypoints = 150, waypoints_seed = 123, flock_waypoints = 2)
```
Arguments

data  Input data matrix.
s  The ID of starting point.
diffusionmap_components  Number of components from diffusion map used for wanderlust analysis, default is 4.
l  Number of nearest neighbors, default is 15.
k  Number of nearest neighbors for repeating graphs, default is 15, should be less than or equal to l.
num_graphs  Number of repeated graphs.
num_waypoints  Number of waypoint used for wanderlust, default is 150.
waypoints_seed  The seed for reproducing the results.
flock_waypoints  The number of times for flocking the waypoints, default is 2.

Value

sorted order.

Author(s)

Hao Chen
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