

# Package ‘cytofkit’

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**Type** Package

**Title** cytofkit: an integrated mass cytometry data analysis pipeline

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**Description** An integrated mass cytometry data analysis pipeline that enables simultaneous illustration of cellular diversity and progression.

**License** Artistic-2.0

**Maintainer**

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**URL** <https://github.com/JinmiaoChenLab/cytofkit>

**BugReports** <https://github.com/JinmiaoChenLab/cytofkit/issues>

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## R topics documented:

cytofkit-package . . . . .	2
ClusterX . . . . .	4
cytofkit . . . . .	5
cytofkitNews . . . . .	7
cytofkitShinyAPP . . . . .	7

cytofkit_GUI . . . . .	8
cytof_addToFCS . . . . .	8
cytof_cluster . . . . .	9
cytof_clusterMtrx . . . . .	10
cytof_clusterPlot . . . . .	10
cytof_clusterStat . . . . .	12
cytof_colorPlot . . . . .	12
cytof_dimReduction . . . . .	13
cytof_exprsExtract . . . . .	14
cytof_exprsMerge . . . . .	15
cytof_heatmap . . . . .	16
cytof_progression . . . . .	17
cytof_progressionPlot . . . . .	18
cytof_writeResults . . . . .	19
DensVM . . . . .	20
fixedLogicleParameters_GUI . . . . .	21
getParameters_GUI . . . . .	21
launchShinyAPP_GUI . . . . .	22
Rphenograph . . . . .	22
spectral1 . . . . .	24
spectral2 . . . . .	24

<b>Index</b>	<b>25</b>
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cytofkit-package	<i>cytofkit: an integrated mass cytometry data analysis pipeline</i>
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## Description

This package is designed to facilitate the analysis workflow of mass cytometry data with automatic subset identification and mapping of cellular progression. Both command line and a GUI client are provided for executing the workflow easily.

## Details

This package integrates merging methods of multiple FCS files, dimension reduction methods (PCA, t-SNE and ISOMAP) and clustering methods (DensVM, ClusterX, and Rphenograph) for rapid subset detection. Analysis results can be visualized and explored interactively using a specially designed shiny web APP, see [cytofkitShinyAPP](#). Moreover, the method `isomap` is provided to map the cellular progression. This workflow can be easily executed with the main function [cytofkit](#) or through the GUI client [cytofkit\\_GUI](#).

### Pre-processing

Using function [cytof\\_exprsMerge](#), one or multiple FCS files will be loaded via the `*read.FCS*` function in the `*flowCore*` package. Then transformation will be applied to the expression value of each FCS file. Transformation methods include `autoLgcl`, `cytofAsinh`, `logicle` and `arcsinh`, where `cytofAsinh` is the default. Then multiple FCS files are merged using one of the merging methods `all`, `min`, `fixed` or `ceil`.

### Dimensionality reduction

Using function [cytof\\_dimReduction](#), t-Distributed Stochastic Neighbor Embedding (`tsne`) is suggested for dimensionality reduction with selected markers, although we also provide methods like `isomap` and `pca`.

### Cluster

Using function `cytof_cluster`, three cluster method are provided, DensVM, ClusterX Rphenograph and FlowSOM. DensVM, densityClustX are performed on the dimension reduced data, while Rphenograph works directed on the high dimensional expression data. Method FlowSOM is integrated from FlowSOM package (<https://bioconductor.org/packages/release/bioc/html/FlowSOM.html>).

### Post-processing

- Using function `cytof_clusterPlot` to visualize the cluster results in a scatter plot, in which dots represent cells, colours indicate their assigned clusters and point shapes represent their belonging samples.

- Using function `cytof_heatmap` to generate heat map to visualize the mean expression of every marker in every cluster. This heat maps is useful to interrogate marker expression to identify each cluster's defining markers.

- Using function `cytof_progressionPlot` to visualize the expression pattern of selected markers against the estimated cellular progression order.

- Using function `cytof_addToFCS` to add any dimension reduced data, cluster results, progression data into the original FCS files, new FCS files will be saved for easy checking with other softwares like FlowJo.

All the above post processing can be automatically implemented and saved using one function `cytof_writeResults`.

### Author(s)

Hao Chen, Jinmiao Chen

### References

<https://github.com/JinmiaoChenLab/cytofkit>

### See Also

`cytofkit`, `cytofkit_GUI`

### Examples

```
## Run on GUI
#cytofkit_GUI() # remove the hash symbol to launch the GUI

## Run on command
dir <- system.file('extdata',package='cytofkit')
file <- list.files(dir, pattern='.fcs$', full=TRUE)
parameters <- list.files(dir, pattern='.txt$', full=TRUE)
## remove the hash symbol to run the following command
#results <- cytofkit(fcsFile = file, markers = parameters)

## Checking the vignettes for more details
if(interactive()) browseVignettes(package = 'cytofkit')
```

---

ClusterX

*Fast clustering by automatic search and find of density peaks*

---

### Description

This package implements the clustering algorithm described by Alex Rodriguez and Alessandro Laio (2014) with improvements of automatic peak detection and parallel implementation

### Usage

```
ClusterX(data, dimReduction = NULL, outDim = 2, dc, gaussian = TRUE,  
  alpha = 0.001, detectHalos = FALSE, SVMhalos = FALSE,  
  parallel = FALSE, nCore = 4)
```

### Arguments

data	A data matrix for clustering.
dimReduction	Dimensionality reduction method.
outDim	Number of dimensions used for clustering.
dc	Distance cutoff value.
gaussian	If TRUE, apply gaussian to estimate the density.
alpha	Significance level for peak detection.
detectHalos	If TRUE, detect the halos.
SVMhalos	If TRUE, Run SVM on cores to assign halos.
parallel	If TRUE, run the algorithm in parallel.
nCore	Number of cores employed for parallel computation.

### Details

ClusterX works on low dimensional data analysis (Dimensionality less than 5). If input data is high dimensional, t-SNE is conducted to reduce the dimensionality.

### Value

A list

### Author(s)

Chen Hao

### Examples

```
iris_unique <- unique(iris) # Remove duplicates  
data <- as.matrix(iris_unique[,1:4])  
ClusterXRes <- ClusterX(data)
```

cytofkit

*cytofkit: an integrated mass cytometry data analysis pipeline***Description**

The main function to drive the cytofkit workflow.

**Usage**

```
cytofkit(fcsFiles = getwd(), markers = "parameter.txt",
  projectName = "cytofkit", ifCompensation = FALSE,
  transformMethod = c("autoLgcl", "cytofAsinh", "logicle", "arcsinh", "none"),
  mergeMethod = c("ceil", "all", "min", "fixed"), fixedNum = 10000,
  dimReductionMethod = c("tsne", "pca", "isomap"),
  clusterMethods = c("Rphenograph", "ClusterX", "DensVM", "FlowSOM", "NULL"),
  visualizationMethods = c("tsne", "pca", "isomap", "NULL"),
  progressionMethod = c("NULL", "diffusionmap", "isomap"), FlowSOM_k = 40,
  seed = NULL, clusterSampleSize = 500, resultDir = getwd(),
  saveResults = TRUE, saveObject = TRUE, openShinyAPP = FALSE, ...)
```

**Arguments**

fcsFiles	It can be either the path where your FCS files are stored or a vector of FCS file names.
markers	It can be either a text file that containing markers to be used for analysis or a vector of the marker names.
projectName	A prefix that will be added to the names of all result files.
ifCompensation	Boolean value, to apply compensation contained in FCS, or a compensation matrix.
transformMethod	Data Transformation method, including autoLgcl, cytofAsinh, logicle and arcsinh, or none to avoid transformation.
mergeMethod	When multiple fcs files are selected, cells can be combined using one of the four different methods including ceil, all, min, fixed. The default option is ceil, up to a fixed number (specified by fixedNum) of cells are sampled without replacement from each fcs file and combined for analysis. all: all cells from each fcs file are combined for analysis. min: The minimum number of cells among all the selected fcs files are sampled from each fcs file and combined for analysis. fixed: a fixed num (specified by fixedNum) of cells are sampled (with replacement when the total number of cell is less than fixedNum) from each fcs file and combined for analysis.
fixedNum	The fixed number of cells to be extracted from each FCS file.
dimReductionMethod	The method used for dimensionality reduction, including tsne, pca and isomap.
clusterMethods	The clustering method(s) used for subpopulation detection, including DensVM, ClusterX, Rphenograph and FlowSOM. Multiple selections are accepted.
visualizationMethods	The method(s) used for visualize the cluster data, including tsne, pca and isomap. Multiple selections are accepted.

progressionMethod	Use the first ordination score of isomap to estimated the progression order of cells, choose NULL to ignore.
FlowSOM_k	Number of clusters for meta clustering in FlowSOM.
seed	Integer to set a seed for reproducible results.
clusterSampleSize	The uniform size of each cluster.
resultDir	The directory where result files will be generated.
saveResults	Save the results, and the post-processing results including scatter plot, heatmap, and statistical results.
saveObject	Save the results into RData objects for loading back to R for further analysis
openShinyAPP	Opens the shinyAPP automatically when the analysis was done, default FALSE.
...	Other arguments passed to cytof_exprsExtract

### Details

cytofkit works as the main function to perform the analysis of one or multiple FCS files. The workflow contains data merging from multiple FCS file, expression data transformation, dimensionality reduction with PCA, isomap or tsne (default), clustering analysis with methods includes DensVM, ClusterX, Rphenograph) and FlowSOM for subpopulation detection, and estimation of cellular progression using isomap. The analysis results can be visualized using scatter plot, heatmap plot or progression plot. Dimension reduced data and cluster labels will be saved back to new copies of FCS files. By default the analysis results will be automatically saved under resultDir for further annotation. Moreover An interactive web application is provided for interactive exploration of the analysis results, see cytofkitShinyAPP.

### Value

a list containing expressionData, dimReductionMethod, visualizationMethods, dimReducedRes, clusterRes, progressionRes, projectName, rawFCSdir and resultDir. If choose 'saveResults = TRUE', results will be saved into files under resultDir.

### Author(s)

Hao Chen, Jinmiao Chen

### References

<https://github.com/JinmiaoChenLab/cytofkit>

### See Also

[cytofkit](#), [cytofkit\\_GUI](#), [cytofkitShinyAPP](#)

### Examples

```
dir <- system.file('extdata', package='cytofkit')
file <- list.files(dir, pattern='.fcs$', full=TRUE)
parameters <- list.files(dir, pattern='.txt$', full=TRUE)
## remove the hash symbol to run the following command
#cytofkit(fcsFile = file, markers = parameters)
```

---

cytofkitNews      *check the package update news*

---

**Description**

check the package update news

**Usage**

```
cytofkitNews()
```

**Value**

Opens .Rd file of package update news

---

cytofkitShinyAPP      *A Shiny APP to interactively visualize the analysis results*

---

**Description**

Take the the RData object file saved by cytofkit as input, automatically load the data and allow exploration of the analysis results with interactive control

**Usage**

```
cytofkitShinyAPP(RData = NULL, onServer = FALSE)
```

**Arguments**

RData	Either the RData object file or data object, if missing, RData file need to be loaded on the ShinyAPP
onServer	Logical value, if TRUE, sets shinyApp host to 0.0.0.0 for other clients to access, otherwise defaults to 127.0.0.1 (local host)

**Value**

Opens shinyApp session for data visualisation

**Author(s)**

Hao Chen

**Examples**

```
d <- system.file('extdata', package = 'cytofkit')
Rdata <- list.files(d, pattern = '.RData$', full.names = TRUE)
#only for interactive sessions, remove hash to run
#cytofkitShinyAPP(Rdata)
```

---

cytofkit_GUI	<i>Function for launching the user friendly GUI client for cytofkit-package</i>
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---

### Description

This GUI provides an easy way to apply cytofkit package. Main parameters for running 'cytofkit' main function were integrated in this GUI, and each parameter has a help button to show the instructions. The cytofkit analysis will be automatically started after submitting.

### Usage

```
cytofkit_GUI()
```

### Value

the GUI for cytofkit-package

### Author(s)

Hao Chen

### References

<http://signbioinfo.github.io/cytofkit/>

### See Also

[cytofkit-package](#), [cytofkit](#)

### Examples

```
#cytofkit_GUI() # remove the hash symbol to run
```

---

cytof_addToFCS	<i>Add data to the original FCS files</i>
----------------	---

---

### Description

Store the new dimension transformed data and cluster data into the exprs matrix in new fcs files under analyzedFCSdir

### Usage

```
cytof_addToFCS(data, rawFCSdir, origSampNames = NULL, analyzedFCSdir,  
transformed_cols = c("tsne_1", "tsne_2"), cluster_cols = c("cluster"),  
clusterIDs = NULL, specifySampleNames = NULL, inLgclTrans = TRUE)
```



**Arguments**

data	The new data matrix to be added in.
rawFCSdir	The directory containing the original fcs files.
origSampNames	Vector of original names of samples, if samples were renamed.
analyzedFCSdir	The directory to store the new fcs files.
transformed_cols	The column name of the dimension transformed data in data.
cluster_cols	The column name of the cluster data in data.
clusterIDs	Table of cell cluster IDs for each clustering method
specifySampleNames	Used only if sample names differ from those in raw fcs.
inLgclTrans	If TRUE, apply the inverse lgcl transformation to the the cluster data before saving

**Value**

New fcs files stored under analyzedFCSdir

---

cytof_cluster	<i>Subset detection by clustering</i>
---------------	---------------------------------------

---

**Description**

Apply clustering algorithms to detect cell subsets. DensVM and ClusterX clustering is based on the transformed ydata and uses xdata to train the model. Rphenograph directly works on high dimensional xdata. FlowSOM is integrated from FlowSOM package (<https://bioconductor.org/packages/release/bioc/html/FlowSOM>)

**Usage**

```
cytof_cluster(ydata = NULL, xdata = NULL, method = c("Rphenograph",
  "ClusterX", "DensVM", "FlowSOM", "NULL"), FlowSOM_k = 40, flowSeed = NULL)
```

**Arguments**

ydata	A matrix of the dimension reduced data.
xdata	A matrix of the expression data.
method	Cluster method including DensVM, densityClustX, Rphenograph and FlowSOM.
FlowSOM_k	Number of clusters for meta clustering in FlowSOM.
flowSeed	Integer to set a seed for FlowSOM for reproducible results.

**Value**

a vector of the clusters assigned for each row of the ydata

**Examples**

```
d<-system.file('extdata', package='cytofkit')
fcsFile <- list.files(d, pattern='.fcs$', full=TRUE)
parameters <- list.files(d, pattern='.txt$', full=TRUE)
markers <- as.character(read.table(parameters, header = FALSE)[, 1])
xdata <- cytof_exprsMerge(fcsFile, mergeMethod = 'fixed', fixedNum = 100)
ydata <- cytof_dimReduction(xdata, markers = markers, method = "tsne")
clusters <- cytof_cluster(ydata, xdata, method = "ClusterX")
```

---

cytof\_clusterMtrx      *Expression values by cluster*

---

**Description**

Generate a matrix of expression values for cells in a cluster

**Usage**

```
cytof_clusterMtrx(analysis_results, clusterMethod = NULL, cluster)
```

**Arguments**

analysis\_results      analysis\_results output of cytofkit to extract expression values from.

clusterMethod      The cluster method of interest. If none is selected, the first one will be used.

cluster      The cluster of interest.

**Value**

A data table with marker expression values of cells in a given cluster

**Examples**

```
dir <- system.file('extdata',package='cytofkit')
file <- list.files(dir ,pattern='.RData$', full=TRUE)
load(file)
cluster2_table <- cytof_clusterMtrx(analysis_results, "Rphenograph", 2)
```

---

cytof\_clusterPlot      *Scatter plot of the cluster results*

---

**Description**

Dot plot visualization of the cluster results, with color indicating different clusters, and shape of different samples.

**Usage**

```
cytof_clusterPlot(data, xlab, ylab, cluster, sample, title = "cluster",
  type = 1, point_size = NULL, addLabel = TRUE, labelSize = 10,
  sampleLabel = TRUE, labelRepel = FALSE, fixCoord = TRUE, clusterColor)
```

**Arguments**

data	The data frame of cluster results, which should contains at least xlab, ylab and cluster.
xlab	The column name of the x axis in input data.
ylab	The column name of the y axis in input data.
cluster	The column name of cluster in input data.
sample	The column name of the sample in input data.
title	The title of the plot.
type	Plot type, 1 indicates combined plot, 2 indicated grid facet plot seperated by samples.
point_size	Size of the dot.
addLabel	If TRUE, add cluster labels.
labelSize	Size of cluster labels.
sampleLabel	If TRUE, use point shapes to represent different samples.
labelRepel	If TRUE, repel the cluste labels to avoid label overlapping.
fixCoord	If TRUE, fix the Cartesian coordinates.
clusterColor	Manually specify the colour of each cluster (mainly for ShinyAPP usage).

**Value**

The ggplot object of the scatter cluster plot.

**Examples**

```
x <- c(rnorm(100, mean = 1), rnorm(100, mean = 3), rnorm(100, mean = 9))
y <- c(rnorm(100, mean = 2), rnorm(100, mean = 8), rnorm(100, mean = 5))
c <- c(rep(1,100), rep(2,100), rep(3,100))
rnames <- paste(paste('sample_', c('A','B','C')), sep = ''), rep(1:100,each = 3), sep='_')
data <- data.frame(dim1 = x, dim2 = y, cluster = c)
rownames(data) <- rnames
data$sample <- "data"
cytof_clusterPlot(data, xlab="dim1", ylab="dim2", cluster="cluster", sample = "sample")
```

---

cytof\_clusterStat      *Statistics of the cluster results*

---

### Description

Calculate the mean or median expression level of each marker for each cluster, or percentage of cell numbers of each cluster for each sample.

### Usage

```
cytof_clusterStat(data, markers, cluster = "cluster", sample,
  statMethod = c("mean", "median", "percentage", "NULL"))
```

### Arguments

data	Input data frame.
markers	The names of markers used for calculation.
cluster	The column name containing cluster labels.
sample	The samples used for calculation.
statMethod	Statistics containing mean, median or percentage.

### Value

A matrix of the statistics results

### Examples

```
m1 <- c(rnorm(300, 10, 2), rnorm(400, 4, 2), rnorm(300, 7))
m2 <- c(rnorm(300, 4), rnorm(400, 16), rnorm(300, 10, 3))
m3 <- c(rnorm(300, 16), rnorm(400, 40, 3), rnorm(300, 10))
m4 <- c(rnorm(300, 7, 3), rnorm(400, 30, 2), rnorm(300, 10))
m5 <- c(rnorm(300, 27), rnorm(400, 40, 1), rnorm(300, 10))
c <- c(rep(1,300), rep(2,400), rep(3,300))
rnames <- paste(paste('sample_', c('A','B','C','D'), sep = ''),
  rep(1:250,each = 4), sep='_')
exprs_cluster <- data.frame(cluster = c, m1 = m1, m2 = m2, m3 = m3, m4 = m4, m5 = m5)
row.names(exprs_cluster) <- rnames
cytof_clusterStat(data = exprs_cluster, cluster = "cluster", statMethod = "mean")
```

---

cytof\_colorPlot      *Plot the data with color-coded marker values*

---

### Description

Plot the data with color-coded marker values

### Usage

```
cytof_colorPlot(data, xlab, ylab, zlab, colorPalette = c("bluered",
  "spectral1", "spectral2", "heat"), limits = range(data), pointSize = 1,
  removeOutlier = TRUE)
```

**Arguments**

data	A dataframe containing the xlab, ylab and zlab.
xlab	The column name of data for x lab.
ylab	The column name of data for y lab.
zlab	The column name of data for z lab.
colorPalette	Color Palette.
limits	Range for z lab, defaults to existing min and max.
pointSize	Size of the point.
removeOutlier	If TRUE, remove the outliers.

**Value**

A ggplot object.

**Examples**

```
x <- c(rnorm(100, mean = 1), rnorm(100, mean = 3), rnorm(100, mean = 9))
y <- c(rnorm(100, mean = 2), rnorm(100, mean = 8), rnorm(100, mean = 5))
c <- rnorm(300, 10, 5)
data <- data.frame(dim1 = x, dim2 = y, marker = c)
cytof_colorPlot(data = data, xlab = "dim1", ylab = "dim2", zlab = "marker")
```

---

cytof\_dimReduction      *Dimension reduction for high dimension data*

---

**Description**

Apply dimension reduction on the cytof expression data, with method `pca`, `tsne`, `diffusionmap` or `isomap`.

**Usage**

```
cytof_dimReduction(data, markers = NULL, method = c("tsne", "pca", "isomap",
  "diffusionmap", "NULL"), distMethod = "euclidean", out_dim = 2,
  tsneSeed = 42, isomap_k = 5, isomap_ndim = NULL,
  isomapFragmentOK = TRUE, ...)
```

**Arguments**

data	Input expression data matrix.
markers	Selected markers for dimension reduction, either marker names/descriptions or marker IDs.
method	Method chosen for dimension reduction, must be one of <code>isomap</code> , <code>pca</code> , <code>diffusionmap</code> or <code>tsne</code> .
distMethod	Method for distance calculation, default is "euclidean", other choices like "manhattan", "cosine", "rankcor"....
out_dim	The dimensionality of the output.
tsneSeed	Set a seed if you want reproducible t-SNE results.

isomap_k	Number of shortest dissimilarities retained for a point, parameter for isomap method.
isomap_ndim	Number of axes in metric scaling, parameter for isomap method.
isomapFragmentOK	What to do if dissimilarity matrix is fragmented, parameter for isomap method.
...	Other parameters passed to the method, check <a href="#">Rtsne</a> , <a href="#">DiffusionMap</a> , <a href="#">isomap</a> .

**Value**

A matrix of the dimension reduced data, with colnames method\_ID, and rownames same as the input data.

**Note**

Currently, diffusionmap will not work with R 3.4.0, due to an issue with the latest CRAN release of its dependency [igraph](#). If this is the case, consider manually updating [igraph](#) using: `install.packages("https://github.com/igraph/rigraph/releases/download/v1.1.0/igraph_1.1.0.zip")`,

**Examples**

```
data(iris)
in_data <- iris[, 1:4]
markers <- colnames(in_data[, 1:4])
out_data <- cytof_dimReduction(in_data, markers = markers, method = "tsne")
```

---

cytof\_exprsExtract      *Extract the expression data from a FCS file with preprocessing*

---

**Description**

Extract the FCS expression data with preprocessing of compensation (for FCM data only) and transformation. Transformation methods includes autoLgcl, cytofAsinh, logicle (customizable) and arcsinh (customizable).

**Usage**

```
cytof_exprsExtract(fcsFile, verbose = FALSE, comp = FALSE,
  transformMethod = c("autoLgcl", "cytofAsinh", "logicle", "arcsinh", "none"),
  scaleTo = NULL, q = 0.05, l_w = 0.1, l_t = 4000, l_m = 4.5,
  l_a = 0, a_a = 1, a_b = 1, a_c = 0)
```

**Arguments**

fcsFile	The name of the FCS file.
verbose	If TRUE, print the message details of FCS loading.
comp	If TRUE, does compensation by compensation matrix contained in FCS. Argument also accepts a compensation matrix to be applied. Otherwise FALSE.
transformMethod	Data Transformation method, including autoLgcl, cytofAsinh, logicle and arcsinh, or none to avoid transformation.

scaleTo	Scale the expression to a specified range c(a, b), default is NULL.
q	Quantile of negative values removed for auto w estimation, default is 0.05, parameter for autoLgcl transformation.
l_w	Linearization width in asymptotic decades, parameter for logicle transformation.
l_t	Top of the scale data value, parameter for logicle transformation.
l_m	Full width of the transformed display in asymptotic decades, parameter for logicle transformation.
l_a	Additional negative range to be included in the display in asymptotic decades, parameter for logicle transformation.
a_a	Positive double that corresponds to the base of the arcsinh transformation, $\text{arcsinh} = \text{asinh}(a + b * x) + c$ .
a_b	Positive double that corresponds to a scale factor of the arcsinh transformation, $\text{arcsinh} = \text{asinh}(a + b * x) + c$ .
a_c	Positive double that corresponds to another scale factor of the arcsinh transformation, $\text{arcsinh} = \text{asinh}(a + b * x) + c$ .

### Value

A transformed expression data matrix, row names added as filename\_cellID, column names added as name<desc>.

### Examples

```
d <- system.file('extdata', package='cytofkit')
fcsFile <- list.files(d, pattern='.fcs$', full=TRUE)
transformed <- cytof_exprsExtract(fcsFile)
```

---

cytof_exprsMerge	<i>Merge the expression matrix from multiple FCS files with preprocessing</i>
------------------	---

---

### Description

Apply preprocessing on each FCS file including compensation (for FCM data only) and transformation with selected markers, then expression matrix are extracted and merged using one of the methods, all, min, fixed or ceil

### Usage

```
cytof_exprsMerge(fcsFiles, comp = FALSE, transformMethod = c("autoLgcl",
  "cytofAsinh", "logicle", "arcsinh", "none"), scaleTo = NULL,
  mergeMethod = c("ceil", "all", "fixed", "min"), fixedNum = 10000,
  sampleSeed = 123, ...)
```

**Arguments**

fcsFiles	A vector of FCS file names.
comp	If TRUE, does compensation by compensation matrix contained in FCS. Argument also accepts a compensation matrix to be applied. Otherwise FALSE.
transformMethod	Data Transformation method, including autoLgcl, cytofAsinh, logicle and arcsinh, or none to avoid transformation.
scaleTo	Scale the expression to a specified range c(a, b), default is NULL.
mergeMethod	Merge method for mutiple FCS expression data. cells can be combined using one of the four different methods including ceil, all, min, fixed. The default option is ceil, up to a fixed number (specified by fixedNum) of cells are sampled without replacement from each fcs file and combined for analysis. all: all cells from each fcs file are combined for analysis. min: The minimum number of cells among all the selected fcs files are sampled from each fcs file and combined for analysis. fixed: a fixed num (specified by fixedNum) of cells are sampled (with replacement when the total number of cell is less than fixedNum) from each fcs file and combined for analysis.
fixedNum	The fixed number of cells to be extracted from each FCS file.
sampleSeed	A sampling seed for reproducible expression matrix merging.
...	Other arguments passed to cytof_exprsExtract

**Value**

A matrix containing the merged expression data, with selected markers, row names added as filename\_cellID, column names added as name<desc>.

**See Also**

[cytof\\_exprsExtract](#)

**Examples**

```
d<-system.file('extdata',package='cytofkit')
fcsFiles <- list.files(d,pattern='.fcs$',full=TRUE)
merged <- cytof_exprsMerge(fcsFiles)
```

---

cytof\_heatmap

*Heatmap plot of cluster mean value results*

---

**Description**

Heatmap plot of cluster mean value results

**Usage**

```
cytof_heatmap(data, baseName = "Cluster", scaleMethod = "none",
  dendrogram = c("both", "row", "column", "none"), colPalette = c("bluered",
  "greenred", "spectral1", "spectral2"), cex_row_label = NULL,
  cex_col_label = NULL, key.par = list(mgp = c(1.5, 0.5, 0), mar = c(3, 2.5,
  3.5, 1)), keysize = 1.4, margins = c(5, 5))
```



**Arguments**

data	A matrix with rownames and colnames
baseName	The name as a prefix in the title of the heatmap.
scaleMethod	Method indicating if the values should be centered and scaled in either the row direction or the column direction, or none. The default is 'none'.
dendrogram	Control the dendrogram on row or column, selection includes 'both', 'row', 'column', 'none'.
colPalette	Use selected colour palette, includes 'bluered', 'greenred', 'spectral1' and 'spectral2'.
cex_row_label	Text size for row labels.
cex_col_label	Text size for column labels.
key.par	Graphical parameters for the color key.
keysize	Numeric value indicating the size of the key.
margins	Numeric vector of length 2 containing the margins (see par(mar=*)) for column and row names, respectively.

**Value**

A heatmap object from gplots

**Examples**

```

m1 <- c(rnorm(300, 10, 2), rnorm(400, 4, 2), rnorm(300, 7))
m2 <- c(rnorm(300, 4), rnorm(400, 16), rnorm(300, 10, 3))
m3 <- c(rnorm(300, 16), rnorm(400, 40, 3), rnorm(300, 10))
m4 <- c(rnorm(300, 7, 3), rnorm(400, 30, 2), rnorm(300, 10))
m5 <- c(rnorm(300, 27), rnorm(400, 40, 1), rnorm(300, 10))
c <- c(rep(1,300), rep(2,400), rep(3,300))
rnames <- paste(paste('sample_', c('A','B','C','D'), sep = ''),
rep(1:250,each = 4), sep='_')
exprs_cluster <- data.frame(cluster = c, m1 = m1, m2 = m2, m3 = m3, m4 = m4, m5 = m5)
rownames(exprs_cluster) <- sample(rnames, 1000)
cluster_mean <- aggregate(. ~ cluster, data = exprs_cluster, mean)
rownames(cluster_mean) <- paste("cluster_", cluster_mean$cluster, sep = "")
cytof_heatmap(cluster_mean[, -which(colnames(cluster_mean) == "cluster")])

```

---

cytof\_progression      *Progression estimation of cytof expression data*

---

**Description**

Infer the progression based on the relationship of cell subsets estimated using ISOMAP or Diffusion map.

**Usage**

```

cytof_progression(data, cluster, method = c("diffusionmap", "isomap", "NULL"),
distMethod = "euclidean", out_dim = 2, clusterSampleMethod = c("ceil",
"all", "fixed", "min"), clusterSampleSize = 500, sampleSeed = 123)

```

**Arguments**

data	Expression data matrix.
cluster	A vector of cluster results for the data.
method	Method for estimation of cell progression, isomap or diffusionmap.
distMethod	Method for distance calculation, default is "euclidean", other choices like "manhattan", "cosine", "rankcor".
out_dim	Number of transformed dimensions chosen for output.
clusterSampleMethod	Cluster sampling method including ceil, all, min, fixed. The default option is ceil, up to a fixed number (specified by fixedNum) of cells are sampled without replacement from each cluster and combined for analysis. all: all cells from each cluster are combined for analysis. min: The minimum number of cells among all clusters are sampled from cluster and combined for analysis. fixed: a fixed num (specified by fixedNum) of cells are sampled (with replacement when the total number of cell is less than fixedNum) from each cluster and combined for analysis.
clusterSampleSize	The number of cells to be sampled from each cluster.
sampleSeed	The seed for random down sample of the clusters.

**Value**

a list. Includes: sampleData, sampleCluster and progressionData.

**Examples**

```
d<-system.file('extdata', package='cytofkit')
fcsFile <- list.files(d, pattern='.fcs$', full=TRUE)
parameters <- list.files(d, pattern='.txt$', full=TRUE)
markers <- as.character(read.table(parameters, header = TRUE)[, 1])
xdata <- cytof_exprsMerge(fcsFile, mergeMethod = 'fixed', fixedNum = 2000)
clusters <- cytof_cluster(xdata = xdata, method = "Rphenograph")
prog <- cytof_progression(data = xdata, cluster = clusters, clusterSampleSize = 100)
d <- as.data.frame(cbind(prog$progressionData, cluster = factor(prog$sampleCluster)))
cytof_clusterPlot(data =d, xlab = "diffusionmap_1", ylab="diffusionmap_2",
                  cluster = "cluster", sampleLabel = FALSE)
```

---

cytof\_progressionPlot *Progression plot*

---

**Description**

Plot the expression trend along the estimated cell progressing order

**Usage**

```
cytof_progressionPlot(data, markers, clusters, orderCol = "isomap_1",
                     clusterCol = "cluster", reverseOrder = FALSE, addClusterLabel = TRUE,
                     clusterLabelSize = 5, segmentSize = 0.5, min_expr = NULL,
                     trend_formula = "expression ~ sm.ns(Pseudotime, df=3)")
```

**Arguments**

data	The data frame for progression plot.
markers	The column names of the selected markers for visualization.
clusters	Select clusters for plotting, default selects all.
orderCol	The column name of the estimated cell progression order.
clusterCol	The column name of the cluster results.
reverseOrder	If TRUE, reverse the value of orderCol.
addClusterLabel	If TRUE, add the cluster label on the plot.
clusterLabelSize	Size of the cluster label.
segmentSize	Size of the cluster label arrow.
min_expr	The threshold of the minimal expression value for markers.
trend_formula	A symbolic description of the model to be fit.

**Value**

A ggplot2 object

**Examples**

```
m1 <- c(rnorm(300, 10, 2), rnorm(400, 4, 2), rnorm(300, 7))
m2 <- c(rnorm(300, 4), rnorm(400, 16), rnorm(300, 10, 3))
m3 <- c(rnorm(300, 16), rnorm(400, 40, 3), rnorm(300, 10))
m4 <- c(rnorm(300, 7, 3), rnorm(400, 30, 2), rnorm(300, 10))
m5 <- c(rnorm(300, 27), rnorm(400, 40, 1), rnorm(300, 10))
c <- c(rep(1,300), rep(2,400), rep(3,300))
rnames <- paste(paste('sample_', c('A','B','C','D'), sep = ''),
rep(1:250,each = 4), sep='_')
exprs_cluster <- data.frame(cluster = c, m1 = m1, m2 = m2, m3 = m3, m4 = m4, isomap_1 = m5)
row.names(exprs_cluster) <- sample(rnames, 1000)
cytof_progressionPlot(exprs_cluster, markers = c("m1", "m2", "m3", "m4"))
```

---

cytof\_writeResults      *Save the cytofkit analysis results*

---

**Description**

Save analysis results from cytofkit main function to RData, csv files and PDF files and add them to a new copy of FCS files.

**Usage**

```
cytof_writeResults(analysis_results, projectName, saveToRData = TRUE,
saveToFCS = TRUE, saveToFiles = TRUE, resultDir, rawFCSdir,
inverseLgclTrans = TRUE)
```

**Arguments**

analysis_results	Result data from output of <a href="#">cytofkit</a>
projectName	A prefix that will be added to the names of result files.
saveToRData	Boolean value determines if results object is saved into RData file, for loading back to R and to shiny APP.
saveToFCS	Boolean value determines if results are saved back to FCS files, new FCS files will be generated under folder XXX_analyzedFCS.
saveToFiles	Boolean value determines if results are parsed and automatically saved to csv files and pdf figures.
resultDir	The directory where result files will be generated.
rawFCSdir	The directory that contains fcs files to be analysed.
inverseLgclTrans	If TRUE, inverse logicle transform the cluster cor1 and cor2 channels.

**Value**

Save all results in the resultDir

**See Also**

[cytofkit](#)

**Examples**

```
d <- system.file('extdata',package='cytofkit')
f <- list.files(d, pattern='.fcs$', full=TRUE)
p <- list.files(d, pattern='.txt$', full=TRUE)
#tr <- cytofkit(fcsFile=f,markers=p,projectName='t',saveResults=FALSE)
#cytof_write_results(tr,projectName = 'test',resultDir=d,rawFCSdir =d)
```

---

DensVM

*Density-based local maxima cluster with SVM*

---

**Description**

Density-based local maxima peak finding, subpopulation assigning with the power of SVM

**Usage**

```
DensVM(ydata, xdata)
```

**Arguments**

ydata	a matrix of the dimension reduced(transformed) data
xdata	a matrix of the expression data

**Value**

a list contains a matrix peakdata of the peak numbers with different kernel bandwidth, and a matrix clusters of the cluster results

**Author(s)**

Chen Jinmiao

**Examples**

```
d<-system.file('extdata',package='cytofkit')
fcsFile <- list.files(d,pattern='.fcs$',full=TRUE)
xdata <- cytof_exprsMerge(fcsFile, mergeMethod = 'fixed', fixedNum = 100)
ydata <- cytof_dimReduction(xdata)
#clusters <- DensVM(ydata, xdata)
```

---

fixedLogicleParameters\_GUI

*GUI for getting parameter for logicle transformation*

---

**Description**

Extract the parameter for fixed logicle transformation

**Usage**

```
fixedLogicleParameters_GUI(fixedLgclParas = c(0.5, 5e+05, 4.5, 0))
```

**Arguments**

fixedLgclParas parameters vector containing w, t, m, a

**Value**

Parameters for fixed logicle transformation

**Examples**

```
#fixedLogicleParameters_GUI
```

---

getParameters\_GUI

*GUI for marker selection*

---

**Description**

Extract the markers from the fcsfiles

**Usage**

```
getParameters_GUI(fcsFile, rawFCSdir)
```

**Arguments**

fcsFile	The name of the FCS file
rawFCSdir	The path of the FCS file

**Value**

List of markers for ddimension reduction and clustering

**Examples**

```
#getParameters_GUI()
```

---

launchShinyAPP_GUI	<i>GUI for launching shiny APP</i>
--------------------	------------------------------------

---

**Description**

A shiny APP for interactive exploration of analysis results

**Usage**

```
launchShinyAPP_GUI(message = "cytofkit", dir = getwd(), obj = NULL)
```

**Arguments**

message	Message when asking if user wants to open the shiny APP
dir	Result directory.
obj	The RData piped from cytofkit function to the Shiny App

**Value**

Window asking user if they wish to open shinyApp directly

**Examples**

```
# launchShinyAPP_GUI()
```

---

Rphenograph	<i>RphenoGraph clustering</i>
-------------	-------------------------------

---

**Description**

R implementation of the phenograph algorithm

**Usage**

```
Rphenograph(data, k = 30)
```

**Arguments**

data	Input data matrix.
k	Number of nearest neighbours, default is 30.

**Details**

A simple R implementation of the phenograph [PhenoGraph]([http://www.cell.com/cell/abstract/S0092-8674\(15\)00637-6](http://www.cell.com/cell/abstract/S0092-8674(15)00637-6)) algorithm, which is a clustering method designed for high-dimensional single-cell data analysis. It works by creating a graph ("network") representing phenotypic similarities between cells by calculating the Jaccard coefficient between nearest-neighbor sets, and then identifying communities using the well known [Louvain method](<https://sites.google.com/site/findcommunities/>) in this graph.

**Value**

a communities object, the operations of this class contains:

<code>print</code>	returns the communities object itself, invisibly.
<code>length</code>	returns an integer scalar.
<code>sizes</code>	returns a numeric vector.
<code>membership</code>	returns a numeric vector, one number for each vertex in the graph that was the input of the community detection.
<code>modularity</code>	returns a numeric scalar.
<code>algorithm</code>	returns a character scalar.
<code>crossing</code>	returns a logical vector.
<code>is_hierarchical</code>	returns a logical scalar.
<code>merges</code>	returns a two-column numeric matrix.
<code>cut_at</code>	returns a numeric vector, the membership vector of the vertices.
<code>as.dendrogram</code>	returns a dendrogram object.
<code>show_trace</code>	returns a character vector.
<code>code_len</code>	returns a numeric scalar for communities found with the InfoMAP method and NULL for other methods.
<code>plot</code>	for communities objects returns NULL, invisibly.

**Author(s)**

Chen Hao

**References**

Jacob H. Levine and et.al. Data-Driven Phenotypic Dissection of AML Reveals Progenitor-like Cells that Correlate with Prognosis. *Cell*, 2015.

**Examples**

```
iris_unique <- unique(iris) # Remove duplicates
data <- as.matrix(iris_unique[,1:4])
Rphenograph_out <- Rphenograph(data, k = 45)
```

---

`spectral1`*First Function for spectral color palette*

---

**Description**

First Function for spectral color palette

**Usage**`spectral1(n)`**Arguments**

`n`                      Number of colors.

**Value**

Hex colour values

**Examples**`spectral1(2)`

---

`spectral2`*Second Function for spectral color palette*

---

**Description**

Second Function for spectral color palette

**Usage**`spectral2(n)`**Arguments**

`n`                      Number of colors.

**Value**

Hex colour values

**Examples**`spectral2(2)`



# Index

ClusterX, [4](#)  
cytof\_addToFCS, [3](#), [8](#)  
cytof\_cluster, [3](#), [9](#)  
cytof\_clusterMtrx, [10](#)  
cytof\_clusterPlot, [3](#), [10](#)  
cytof\_clusterStat, [12](#)  
cytof\_colorPlot, [12](#)  
cytof\_dimReduction, [2](#), [13](#)  
cytof\_exprsExtract, [14](#), [16](#)  
cytof\_exprsMerge, [2](#), [15](#)  
cytof\_heatmap, [3](#), [16](#)  
cytof\_progression, [17](#)  
cytof\_progressionPlot, [3](#), [18](#)  
cytof\_writeResults, [3](#), [19](#)  
cytofkit, [2](#), [3](#), [5](#), [6](#), [8](#), [20](#)  
cytofkit-package, [2](#)  
cytofkit\_GUI, [2](#), [3](#), [6](#), [8](#)  
cytofkitNews, [7](#)  
cytofkitShinyAPP, [2](#), [6](#), [7](#)  
  
DensVM, [20](#)  
DiffusionMap, [14](#)  
  
fixedLogicleParameters\_GUI, [21](#)  
  
getParameters\_GUI, [21](#)  
  
igraph, [14](#)  
isomap, [14](#)  
  
launchShinyAPP\_GUI, [22](#)  
  
Rphenograph, [22](#)  
Rtsne, [14](#)  
  
spectral1, [24](#)  
spectral2, [24](#)