Package ‘flowType’

November 12, 2018

Type Package
Title Phenotyping Flow Cytometry Assays
Version 2.20.0
Date 2014-11-26
Author Nima Aghaeepour, Kieran O’Neill, Adrin Jalali
Maintainer Nima Aghaeepour <naghaeep@gmail.com>
Description Phenotyping Flow Cytometry Assays using multidimensional expansion of single dimensional partitions.
Imports Biobase, graphics, grDevices, methods, flowCore, flowMeans, sfsmisc, rrcov, flowClust, flowMerge, stats
Depends R (>= 2.10), Rcpp (>= 0.10.4), BH (>= 1.51.0-3)
LinkingTo Rcpp, BH
Suggests xtable
biocViews FlowCytometry
License Artistic-2.0
LazyLoad yes
git_url https://git.bioconductor.org/packages/flowType
git_branch RELEASE_3_8
git_last_commit 9389930
git_last_commit_date 2018-10-30
Date/Publication 2018-11-11

R topics documented:

flowType-package ................................................. 2
calcMemUse ....................................................... 3
calcNumPops ...................................................... 4
decodePhenotype ................................................ 5
DLBCLExample .................................................. 6
encodePhenotype ............................................... 6
flowType .......................................................... 7
getLabels .......................................................... 9
HIVData ............................................................ 10
HIVMetaData ...................................................... 10
flowType-package

Description

flowType uses a simple threshold, Kmeans, flowMeans, or flowClust to partition every channel to a positive and a negative cell population. These partitions are then combined to generate a set of multi-dimensional phenotypes.

Details

Package: flowType
Type: Package
Version: 0.0.1
Date: 2011-04-27
License: Artistic-2.0
LazyLoad: yes
Depends: methods

For a given FCS file, the flowType function extracts a the phenotypes and reports their cell frequencies (number of cells) and mean fluorescence intensity (MFI)s.

Author(s)

Nima Aghaeepour, Kieran O’Neill, Adrin Jalali

References

Please cite the following for the current version of flowType:


The original paper and description can be found at:


Examples

#Load the library
library(flowType)
data(DLBCLExample)

# These markers will be analyzed
PropMarkers <- 3:5
MFIMarkers <- PropMarkers
MarkerNames <- c("FS", "SS", "CD3", "CD5", "CD19")

# Run flowType
Res <- flowType(DLBCLExample, PropMarkers, MFIMarkers, 'kmeans', MarkerNames);

MFIs=Res@MFIs;
Proportions=Res@CellFreqs;
Proportions <-Proportions / max(Proportions)

names(Proportions) <- unlist(lapply(Res@PhenoCodes,
  function(x){return(decodePhenotype(x,Res@MarkerNames[PropMarkers],
  Res@PartitionsPerMarker))}))

# Select the 30 largest phenotypes
index=order(Proportions,decreasing=TRUE)[1:30]
bp=barplot(Proportions[index], axes=FALSE, names.arg=FALSE)
text(bp+0.2, par("usr")[3]+0.02, srt = 90, adj = 0, labels = names(Proportions[index]), xpd = TRUE, cex=0.8)
axis(2); axis(1, at=bp, labels=FALSE);
title(xlab="Phenotype Names", ylab="Cell Proportion")

# These phenotype can be analyzed using a predictive model (e.g., classification or regression)

calcMemUse

Function calcMemUse in Package flowType

Description
Estimates the memory usage in bytes for running flowType with a given set of parameters.

Usage

calcMemUse(NumPops, NumPropMarkers, NumMFIMarkers, NumCells, MaxMarkersPerPop, PartitionsPerChannel)

Arguments

NumPops Number of cell types which will be returned. Can be computed using calcNumPops
NumPropMarkers Number of markers to use for combinatorial gating
NumMFIMarkers Number of markers to determine the MFIs of for every cell type
NumCells Number of cells in the flowFrame passed to flowType
MaxMarkersPerPop Maximum number of markers to use at once in combinatorial gating (i.e., cell types over 1:MaxMarkersPerPop will be counted)
PartitionsPerChannel Number of partitions per channel.
calcNumPops

Details

If you use different numbers of partitions for different channels, try providing the highest number as PartitionsPerChannel, and expect an over-estimate.

Value

Estimated memory use in bytes.

Author(s)

Kieran O’Neill

See Also

calcNumPops, flowType

calcNumPops Function calcNumPops in Package flowType

Description

Compute the number of populations that will be produced by running flowType with a given set of parameters. This is especially useful for estimating memory but is also used internally to determine the size of return objects to pass down to C++. This may also be useful for determining the cutoff for number of markers to use to make phenotypes (in terms of statistical power for later testing).

Usage

calcNumPops(PartitionsPerMarker, MaxMarkersPerPop)

Arguments

PartitionsPerMarker

Integer vector specifying the number of partitions for each marker, in order.

MaxMarkersPerPop

Integer specifying the threshold chosen

Value

Integer specifying the number of populations the given parameters would produce.

Author(s)

Kieran O’Neill

See Also

calcMemUse, flowType

Examples

calcNumPops(c(2,2,3,2,2,4), 5)
Method `decodePhenotype` in Package `flowType`

**Description**

Method to decode phenotypes back to a human-readable string.

**Details**

FlowType's encoding is as follows:

0 – marker not considered in phenotype (don’t care about its value)  1 – marker is negative (e.g. CD4-) 2 – marker is positive (e.g. CD4+)  3 – marker is positive, but brighter than 2 (CD4++)  4 – marker is even brighter (CD4+++ etc)

Note that this encoding system does not allow for "dim" markers – dim positivity is denoted by the first level of positivity.

Also note that the encoding is performed from the dimmest to the brightest partition, but the location of thresholds will dictate the interpretation of the code. (e.g. if you only set one threshold, but you place it between the positive and the bright population, then both positive and negative events will be considered negative.)

**Methods**

```r
signature(pheno.code = "character", marker.names = "character", partitions.per.marker = "numeric")
```

In `flowType`, phenotypes themselves are represented by codes (e.g. 012) rather than full strings (CD4+CD8-), in order to save memory when a very large number of phenotypes are considered. `decodePhenotype` serves to translate the codes back to a human-readable string.

**Author(s)**

Kieran O’Neill

**See Also**

`encodePhenotype`, `flowType`

**Examples**

```r
decodePhenotype("1034",c("CD34","CD3","CD45","CD19"), 4)
decodePhenotype("20013",c("CD34","CD3","CD45","CD19", "CD20"), 4)
```
DLBCLExample

**Description**

A flow cytometry sample from a patient with DLBC lymphoma. The full dataset is available through the FlowCAP project (http://flowcap.flowsite.org).

**Usage**

data(DLBCLExample)

**Format**

A `flowFrame` describing expression values of 3 markers and 3796 cells. Each column represents a marker and each row represents a cell.

**Examples**

data(DLBCLExample)

---

**Function encodePhenotype in Package flowType**

**Description**

In `flowType`, phenotypes themselves are represented by codes (e.g. 012) rather than full strings (CD4+CD8-), in order to save memory when a very large number of phenotypes are considered. `encodePhenotype` serves to translate a human-readable string down to `flowType`'s internal coded representation.

**Usage**

`encodePhenotype(pheno.string, marker.names)`

**Arguments**

- `pheno.string` character vector containing containing the phenotype string to be encoded
- `marker.names` vector of character vectors each specifying the name of a channel, in order

**Details**

`FlowType`'s encoding is as follows:

- 0 – marker not considered in phenotype (don’t care about its value)
- 1 – marker is negative (e.g. CD4-)
- 2 – marker is positive (e.g. CD4+)
- 3 – marker is positive, but brighter than 2 (CD4++)
- 4 – marker is even brighter (CD4+++)

Note that this encoding system does not allow for "dim" markers – dim positivity is denoted by the first level of positivity.
flowType

Also note that the encoding is performed from the dimmest to the brightest partition, but the location of thresholds will dictate the interpretation of the code. (e.g. if you only set one threshold, but you place it between the positive and the bright population, then both positive and negative events will be considered negative.)

Value
Character vector containing the encoded phenotype, with one character per channel.

Author(s)
Kieran O’Neill

See Also
decodePhenotype, flowType

Examples

codePhenotype("CD34++CD3-CD45+++", c("CD34", "CD3", "CD45", "CD19"))

Description
flowType uses a simple threshold, Kmeans, flowMeans or flowClust to partition every channel to a positive and a negative cell population. These partitions are then combined to generate a set of multi-dimensional phenotypes.

Usage
flowType(Frame, PropMarkers=NULL, MFIMarkers=NULL, Methods="kmeans", MarkerNames=NULL, MaxMarkersPerPop=NULL, Thresholds=NULL, MemLimit=4, verbose=FALSE)

Arguments
Frame A flowFrame (after transformation) that is going to be phenotyped.
PropMarkers A vector of the indexes or names of the markers to partition to specify phenotypes. If NULL, all markers in the frame will be used.
MFIMarkers A vector of the indexes or names of the markers for which MFIs must be measured. If NULL, no markers will be used.
Methods A single string specifying the method to use to determine thresholds for partitioning of markers. Values can be "kmeans", "flowMeans", "flowClust", or "Thresholds". If "Thresholds" is specified, user-specified thresholds must be provided via the Thresholds parameter.
MarkerNames A vector of names for the channels. If NULL, the names in Frame will be used.
MaxMarkersPerPop An integer specifying the maximum number of markers to use to define populations (how "deep" to phenotype). This should be less than or equal to PropMarkers. If NULL, will default to the length of PropMarkers.
PartitionsPerMarker

An integer or vector of integers specifying the number of partitions per marker. If a single integer, this number will be used for all markers. If a vector, the numbers will be matched with PropMarkers in order.

Thresholds

A list of vectors specifying per-channel thresholds. Each list item corresponds to one marker, and contains the threshold(s) for that marker. If only one vector is provided in the list, then those thresholds will be used for all markers. Otherwise, the list must be of the same length as PropMarkers. Note: if Methods == 'thresholds', then Thresholds must be specified. If not, it is ignored.

MemLimit

Memory limit in GB. flowType will do a sanity check before executing, and if the total size of counts plus MFI values for all populations would exceed MemLimit, will not run.

verbose

Boolean variable. If TRUE, information about different processing tasks will be printed into the standard output.

Value

CellFreqs: Object of class "numeric" containing the cell frequencies measured for each phenotype. Phenotype names are assigned as labels.

MFIs: Object of class "matrix" containing the measured MFIs for each phenotype. Phenotype names are assigned as column labels and marker names as row labels.

PropMarkers A vector of the indexes or names of the markers for which cell proportions must be measured.

MFIMarkers A vector of the indexes or names of the markers for which MFIs must be measured.

MarkerNames A vector of names for the channels. If NULL, the names provided in Frame will be used.

Partitions A matrix where each column shows the partitioning of the respective channel. 1 and 2 correspond to negative and positive, respectively.

PhenoCodes A vector of strings of length N (the number of markers) for each phenotype measured. For every phenotype, the character corresponding to a given marker can be 0, 1, 2, etc for neutral, negative, positive, bright, etc. See the provided vignette for more details and examples.

Author(s)

Nima Aghaeepour, Kieran O’Neill

References

Please cite the following for the current version of flowType:


The original paper and description can be found at:

getLabels

Examples

#Load the library
library(flowType)
data(DLBCLExample)

#These markers will be analyzed
PropMarkers <- 3:5
MFIMarkers <- PropMarkers
MarkerNames <- c('FS', 'SS','CD3','CD5','CD19')

#Run flowType
Res <- flowType(DLBCLExample, PropMarkers, MFIMarkers, 'kmeans', MarkerNames);

MFIs=Res@MFIs;
Proportions=Res@CellFreqs;
Proportions <- Proportions / max(Proportions)
names(Proportions) <- unlist(lapply(Res@PhenoCodes,
  function(x){return(decodePhenotype(
    x,Res@MarkerNames[PropMarkers],
    Res@PartitionsPerMarker))}))

#Select the 30 largest phenotypes
index=order(Proportions,decreasing=TRUE)[1:30]
bp=barplot(Proportions[index], axes=FALSE, names.arg=FALSE)
text(bp+0.2, par("usr")[3]+0.02, srt = 90, adj = 0, labels = names(Proportions[index]), xpd = TRUE, cex=0.8)
axis(2);
axis(1, at=bp, labels=FALSE);
title(xlab="Phenotype Names", ylab='Cell Proportion')

#These phenotype can be analyzed using a predictive model (e.g., classification or regression)

getLabels

getLabels: Returns the labels of the cells in a given phenotype.

Description

Returns the labels of the cells in a given phenotype in a Phenotypes object.

Usage

getLabels(Phenotypes, PhenotypeNumber)

Arguments

Phenotypes An object of class Phenotypes as produced by the flowType function.
PhenotypeNumber A numeric or character value representing the phenotypes number of name, respectively.

Value

Membership Labels:

A vector of length of the number of events. 1 and 2 represent the cells that are not-included and included in the phenotype respectively.
**Author(s)**
Nima Aghaeepour

**References**

**Examples**

```r
#See the vignette
```

---

**HIVData**

**Description**
A flow cytometry dataset from a HIV+ patients PBMC by the Scott lab of the Simon Fraser University and the Spina lab of the University of California San Diego.

**Usage**
data(HIVData)

**Format**
A `flowSet` describing expression values of 11 markers and 500 cells (sampled uniformly) for 19 HIV+ and 12 normal subjects.

**Examples**
data(HIVData)

---

**HIVMetaData**

**Description**
The meta-data of a flow cytometry dataset from a HIV+ patients PBMC by the Scott lab of the Simon Fraser University and the Spina lab of the University of California San Diego.

**Usage**
data(HIVMetaData)

**Format**
A `matrix` describing the FCS filename, patient label (HIV+ or normal) and tube number of every assay.
**Phenotypes-class**

**Examples**

```r
data(HIVMetaData)
```

---

**Description**

The return data from running `flowType`, containing counts

**Objects from the Class**

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

**Slots**

- **CellFreqs**: Numeric vector containing counts of the number of cells belonging to each cell type.
- **MFIs**: Matrix of MFIs, with rows for cell types and columns for markers.
- **PhenoCodes**: Vector of character strings representing the codes of each cell type (phenotype).
- **PropMarkers**: Numeric vector specifying which markers were used for combinatorial gating.
- **MFIMarkers**: Numeric vector specifying for which markers MFIs were computed for each cell type.
- **MarkerNames**: A character vector of the names of all markers in the flowFrame given
- **Partitions**: The first level partitions that each cell in the flowFrame belong to in each channel.
- **MaxPopSize**: `MaxMarkersPerPop`
- **PartitionsPerMarker**: Vector of number of partitions used for each marker
- **Thresholds**: A list of vectors with the calculated thresholds for each marker (if a clustering algorithm was used) or the thresholds provided by the user.

**See Also**

- `flowType`

**Examples**

```r
showClass("Phenotypes")
```
plot

Methods for Function plot

Description
Methods for function plot

Usage

## S4 method for signature 'Phenotypes,flowFrame'
plot(x, y, ...)
## S4 method for signature 'Phenotypes,numeric'
plot(x, y, Frame,...)
## S4 method for signature 'Phenotypes,character'
plot(x, y, Frame,...)

Arguments

x An object of class Phenotypes as generated by the flowType package.
y A flowFrame or a numeric/character value representing the phenotype that needs to be plotted depending on the signature of the function
Frame A flowFrame (might be optional depending on the signature of the function
... Extra parameters that will be passed to the generic plot function

Author(s)
Nima Aghaeepour <<naghaeep@gmail.com>>

See Also
flowType

Examples

#See the vignette

summary-methods

Methods for Function summary

Description

~~ Methods for function summary ~~

Methods

signature(object = "Phenotypes") Prints basic characteristics of a Phenotypes object.

See Also
flowType
Examples

#See the vignette
# Index

*Topic **FlowCytData**  
  flowType, 7  
  flowType-package, 2  
  getLabels, 9  

*Topic **HIV**  
  flowType, 7  
  flowType-package, 2  
  getLabels, 9  

*Topic **classes**  
  Phenotypes-class, 11  

*Topic **classification**  
  flowType, 7  
  flowType-package, 2  
  getLabels, 9  

*Topic **clustering**  
  flowType, 7  
  flowType-package, 2  
  getLabels, 9  

*Topic **datasets**  
  DLBCLExample, 6  
  HIVData, 10  
  HIVMetaData, 10  

*Topic **print**  
  plot, 12  
  summary-methods, 12  

*Topic **utilities**  
  calcMemUse, 3  
  calcNumPops, 4  
  decodePhenotype, 5  
  encodePhenotype, 6  

calcMemUse, 3, 4  
calcNumPops, 3, 4, 4  

decodePhenotype, 5, 7  
decodePhenotype, character, character, numeric-method  
  (decodePhenotype), 5  
decodePhenotype, character, character, numeric-method  
  (decodePhenotype), 5  
decodePhenotype-methods  
  (decodePhenotype), 5  
  DLBCLExample, 6  
  encodePhenotype, 5, 6  
  encodePhenotype, character, character-method  
    (encodePhenotype), 6  
  encodePhenotype-methods  
    (encodePhenotype), 6  
  flowType, 4, 5, 7, 7, 11, 12  
  flowType-package, 2  
  getLabels, 9  
  HIVData, 10  
  HIVMetaData, 10  
  Phenotypes (Phenotypes-class), 11  
  Phenotypes-class, 11  
  plot, 12  
  plot, Phenotypes, character (plot), 12  
  plot, Phenotypes, character-method (plot), 12  
  plot, Phenotypes, flowFrame (plot), 12  
  plot, Phenotypes, flowFrame-method (plot), 12  
  plot, Phenotypes, numeric (plot), 12  
  plot, Phenotypes, numeric-method (plot), 12  
  summary, Phenotypes-method  
    (summary-methods), 12  
  summary-methods, 12