

Package ‘MultiAssayExperiment’

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Title Software for the integration of multi-omics experiments in
Bioconductor

Version 1.8.3

Description MultiAssayExperiment harmonizes data management of multiple assays performed on an overlapping set of specimens. It provides a familiar Bioconductor user experience by extending concepts from SummarizedExperiment, supporting an open-ended mix of standard data classes for individual assays, and allowing subsetting by genomic ranges or rownames.

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MultiAssayExperiment-package

MultiAssayExperiment: Build an integrative multi-assay container

Description

MultiAssayExperiment allows the manipulation of related multiassay datasets with partially overlapping samples, associated metadata at the level of an entire study, and at the level of the "biological unit". The biological unit may be a patient, plant, yeast strain, etc.

Details

The package hierarchy of information:

- study
- experiments
- samples

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See Also

Useful links:

- <https://github.com/waldronlab/MultiAssayExperiment/wiki/MultiAssayExperiment-API>
- Report bugs at <https://github.com/waldronlab/MultiAssayExperiment/issues>

ExperimentList	<i>Construct an ExperimentList object for the MultiAssayExperiment object slot.</i>
----------------	---

Description

The ExperimentList class can contain several different types of data. The only requirements for an ExperimentList class are that the objects contained have the following set of methods: dim, [, dimnames

Usage

```
ExperimentList(...)
```

Arguments

... A named list class object

Value

A ExperimentList class object of experiment data

Examples

```
## Create an empty ExperimentList instance
ExperimentList()

## Create array matrix and AnnotatedDataFrame to create an ExpressionSet class
arraydat <- matrix(data = seq(101, length.out = 20), ncol = 4,
  dimnames = list(
    c("ENST00000294241", "ENST00000355076",
      "ENST00000383706", "ENST00000234812", "ENST00000383323"),
    c("array1", "array2", "array3", "array4")
  ))

colDat <- data.frame(slope53 = rnorm(4),
  row.names = c("array1", "array2", "array3", "array4"))

## SummarizedExperiment constructor
exprdat <- SummarizedExperiment::SummarizedExperiment(arraydat,
  colData = colDat)

## Create a sample methylation dataset
methyldat <- matrix(data = seq(1, length.out = 25), ncol = 5,
  dimnames = list(
    c("ENST00000355076", "ENST00000383706",
      "ENST00000383323", "ENST00000234812", "ENST00000294241"),
```

```

        c("methyl1", "methyl2", "methyl3",
          "methyl4", "methyl5")
    ))

## Create a sample RNASeqGene dataset
rnadat <- matrix(
  data = sample(c(46851, 5, 19, 13, 2197, 507,
                 84318, 126, 17, 21, 23979, 614), size = 20, replace = TRUE),
  ncol = 4,
  dimnames = list(
    c("XIST", "RPS4Y1", "KDM5D", "ENST00000383323", "ENST00000234812"),
    c("samparray1", "samparray2", "samparray3", "samparray4")
  ))

## Create a mock RangedSummarizedExperiment from a data.frame
rangedat <- data.frame(chr="chr2", start = 11:15, end = 12:16,
  strand = c("+", "-", "+", "*", "."),
  samp0 = c(0,0,1,1,1), samp1 = c(1,0,1,0,1), samp2 = c(0,1,0,1,0),
  row.names = paste0("GENE", letters[5:1]))

rangeSE <- SummarizedExperiment::makeSummarizedExperimentFromDataFrame(rangedat)

## Combine to a named list and call the ExperimentList constructor function
assayList <- list(Affy = exprdat, Methyl450k = methylmat, RNASeqGene = rnadat,
  GISTIC = rangeSE)

## Use the ExperimentList constructor
ExpList <- ExperimentList(assayList)

```

ExperimentList-class *A container for multi-experiment data*

Description

The ExperimentList class is a container that builds on the SimpleList with additional checks for consistency in experiment names and length. It contains a SimpleList of experiments with sample identifiers. One element present per experiment performed.

Usage

```

## S4 method for signature 'ExperimentList'
show(object)

## S4 method for signature 'ExperimentList'
isEmpty(x)

## S4 method for signature 'ExperimentList'
dimnames(x)

## S4 method for signature 'ExperimentList'
mergeReplicates(x, replicates = list(),
  simplify = BiocGenerics::mean, ...)

```

```
## S4 method for signature 'ANY,missing'
assay(x, i, ...)

## S4 method for signature 'ExperimentList'
assays(x, ..., withDimnames = TRUE)

## S4 method for signature 'ExperimentList,missing'
assay(x, i, ...)

## S4 method for signature 'ExperimentList,numeric'
assay(x, i, ...)

## S4 method for signature 'ExperimentList,character'
assay(x, i, ...)
```

Arguments

object, x	An ExperimentList object
replicates	mergeReplicates: A list or LogicalList where each element represents a sample and a vector of repeated measurements for the sample
simplify	A function for merging columns where duplicates are indicated by replicates
...	Additional arguments. See details for more information.
i	A scalar character or integer index
withDimnames	logical (default TRUE) whether to return dimension names

Details

Convert from [SimpleList](#) or [list](#) to the multi-experiment data container. When using the **mergeReplicates** method, additional arguments are passed to the given `simplify` function argument (e.g., `na.rm = TRUE`)

Methods (by generic)

- `show`: Show method for [ExperimentList](#) class
- `isEmpty`: check for zero length across all experiments
- `dimnames`: Get the dimension names for an [ExperimentList](#) using [CharacterList](#)
- `mergeReplicates`: Apply the `mergeReplicates` method on the [ExperimentList](#) elements
- `assay`: Obtain the specified assay with a numeric or character reference
- `assays`: Get the assay data from each element in the [ExperimentList](#)

coercion

Convert a [list](#) or [S4 List](#) to an [ExperimentList](#) using the `as()` function.

In the following example, `x` is either a [list](#) or [List](#):

```
\code{as(x, "ExperimentList")}
```

Examples

```
ExperimentList()
```

hasAssay	<i>Checking assay method for any class</i>
----------	--

Description

The hasAssay function is intended for developers who would like to include new classes into a MultiAssayExperiment instance. It checks the methods tables of the assay function for the specified class of the argument.

Usage

```
hasAssay(object)
```

Arguments

object	A MultiAssayExperiment or named list object instance
--------	--

Value

A logical value indicating method availability

Examples

```
lst <- structure(list(), .Names=character())
hasAssay(lst)
```

listToMap	<i>Convert map from data.frame or DataFrame to list and vice versa</i>
-----------	--

Description

The mapToList function provides a convenient way of reordering a data.frame to a list. The listToMap function does the opposite by taking a list and converting it to DataFrame.

Usage

```
listToMap(listmap)

mapToList(dfmap, assayCol = "assay")
```

Arguments

listmap	A named list object containing DataFrames with "primary" and "colname" columns
dfmap	A data.frame or DataFrame object with identifiers in the first column
assayCol	A character vector of length one indicating the assay names column

Value

A [DataFrame](#) class object of names

A list object of DataFrames for each assay

Functions

- `listToMap`: The inverse of the `listToMap` operation

Examples

```
example("MultiAssayExperiment")

## Create a sampleMap from a list using the listToMap function
sampMap <- listToMap(maplist)

## The inverse operation is also available
maplist <- mapToList(sampMap)
```

MatchedAssayExperiment-class

An integrative and matched-samples class for experiment data

Description

This class supports the use of matched samples where an equal number of observations per biological unit are present in all assays.

Usage

```
MatchedAssayExperiment(...)
```

Arguments

... Either a single `MultiAssayExperiment` or the components to create a valid `MultiAssayExperiment`

Value

A `MatchedAssayExperiment` object

Functions

- `MatchedAssayExperiment`: Construct a `MatchedAssayExperiment` class from [MultiAssayExperiment](#) inputs.

See Also

[MultiAssayExperiment](#)

Examples

```
data("miniACC")
acc <- as(miniACC, "MatchedAssayExperiment")
acc
```

miniACC

Adrenocortical Carcinoma (ACC) MultiAssayExperiment

Description

A `MultiAssayExperiment` object providing a reduced version of the TCGA ACC dataset for all 92 patients. RNA-seq, copy number, and somatic mutations are included only for genes whose proteins are included in the reverse-phase protein array. The MicroRNA-seq dataset is also included, with infrequently expressed microRNA removed. Clinical, pathological, and subtype information are provided by `colData(miniACC)`, and some additional details are provided by `metadata(miniACC)`.

Usage

```
miniACC
```

Format

A `MultiAssayExperiment` with 5 experiments, providing:

RNASeq2GeneNorm RNA-seq count data: an `ExpressionSet` with 198 rows and 79 columns

gistic2 Recurrent copy number lesions identified by GISTIC2: a `SummarizedExperiment` with 198 rows and 90 columns

RPPAArray Reverse Phase Protein Array: an `ExpressionSet` with 33 rows and 46 columns.

Rows are indexed by genes, but protein annotations are available from `featureData(miniACC[["RPPAArray"]])`. The source of these annotations is noted in `abstract(miniACC[["RPPAArray"]])`

Mutations Somatic mutations: a matrix with 223 rows and 90 columns. 1 for any kind of non-silent mutation, zero for silent (synonymous) or no mutation.

miRNASeqGene microRNA sequencing: an `ExpressionSet` with 471 rows and 80 columns. Rows not having at least 5 counts in at least 5 samples were removed.

Author(s)

Levi Waldron <lwaldron.research@gmail.com>

Source

<https://github.com/waldronlab/multiassayexperiment-tcga>

References

Zheng S *et al.*: Comprehensive Pan-Genomic Characterization of Adrenocortical Carcinoma. *Cancer Cell* 2016, 29:723-736.

Examples

```

miniACC
metadata(miniACC)
colnames(colData(miniACC))
table(miniACC$vital_status)
longFormat(miniACC["MAPK3", , ], colDataCols = c("vital_status", "days_to_death"))
wideFormat(miniACC["MAPK3", , ], colDataCols = c("vital_status", "days_to_death"))

##
## The following is the code used to create this mini dataset from the full ACC dataset.
## The full ACC MultiAssayExperiment was created by the pipeline at
## https://github.com/waldrnlab/multiassayexperiment-tcga.
## Not run:
## See www.tinyurl.com/MAEOurls for more pre-built TCGA MultiAssayExperiment objects
download.file("http://s3.amazonaws.com/multiassayexperiments/accMAEO.rds",
              destfile = "accMAEO.rds")
library(MultiAssayExperiment)
library(RaggedExperiment) #needed for RaggedExperiment objects by updateObject()
library(Biobase)

acc <- readRDS("accMAEO.rds")
acc <- updateObject(acc)
protmap <- read.csv(paste0("http://genomeportal.stanford.edu/",
                           "pan-tcga/target_selection_send_data",
                           "?filename=Allprotein.txt"), as.is = TRUE
)

RPPAgenes <- Filter(function(x) x != "", protmap$Genes)
RPPAgenes <- unlist(strsplit(RPPAgenes, ","))
RPPAgenes <- unique(RPPAgenes)

miniACC <-
  acc[RPPAgenes, , c("RNASeq2GeneNorm", "gistic2", "RPPAArray", "Mutations")]
mut <- assay(miniACC[["Mutations"]], i = "Variant_Classification")
mut <- ifelse(is.na(mut) | mut == "Silent", 0, 1)

miniACC[["Mutations"]] <- mut
colData(miniACC) <- colData(miniACC)[, c(1:17, 810:822)]

rpparowData <-
  protmap[match(rownames(miniACC[["RPPAArray"]]), protmap$Genes),]
rpparowData <- AnnotatedDataFrame(rpparowData)
featureData(miniACC[["RPPAArray"]]) <- rpparowData

md <-
  list(
    title = "Comprehensive Pan-Genomic Characterization of Adrenocortical Carcinoma",
    PMID = "27165744",
    sourceURL = "http://s3.amazonaws.com/multiassayexperiments/accMAEO.rds",
    RPPAfeatureDataURL = paste0("http://genomeportal.stanford.edu/",
                                "pan-tcga/show_target_selection_file",
                                "?filename=Allprotein.txt"),
    colDataExtrasURL = "http://www.cell.com/cms/attachment/2062093088/2063584534/mmc3.xlsx"
  )
metadata(miniACC) <- md

```

```

mirna <- acc[["miRNASeqGene"]]
mirna <- mirna[rowSums(assay(mirna) >= 5) >= 5, ]
experimentData(mirna)@abstract <-
  "Note: Rows not having at least 5 counts in at least 5 samples were removed."
miniACC <- c(miniACC,
             list(miRNASeqGene = mirna),
             sampleMap = sampleMap(acc)[sampleMap(acc)$assay == "miRNASeqGene",])

miniACC[["RNASeq2GeneNorm"]] <-
  as(miniACC[["RNASeq2GeneNorm"]], "SummarizedExperiment")
miniACC[["RPPAArray"]] <-
  as(miniACC[["RPPAArray"]], "SummarizedExperiment")
miniACC[["miRNASeqGene"]] <-
  as(miniACC[["miRNASeqGene"]], "SummarizedExperiment")

save(miniACC, file = "data/miniACC.RData", compress = "bzip2")

## End(Not run)

```

MultiAssayExperiment *Construct a MultiAssayExperiment object*

Description

The constructor function for the [MultiAssayExperiment-class](#) combines multiple data elements from the different hierarchies of data (study, experiments, and samples). It can create instances where neither a `sampleMap` or a `colData` set is provided. Please see the `MultiAssayExperiment` API documentation for more information.

Usage

```

MultiAssayExperiment(experiments = ExperimentList(),
                     colData = S4Vectors::DataFrame(),
                     sampleMap = S4Vectors::DataFrame(assay = factor(), primary =
character(), colname = character()), metadata = NULL, drops = list())

```

Arguments

<code>experiments</code>	A list or ExperimentList of all combined experiments
<code>colData</code>	A DataFrame or <code>data.frame</code> of characteristics for all biological units
<code>sampleMap</code>	A <code>DataFrame</code> or <code>data.frame</code> of assay names, sample identifiers, and <code>colname</code> samples
<code>metadata</code>	An optional argument of "ANY" class (usually list) for content describing the experiments
<code>drops</code>	A list of unmatched information (included after subsetting)

Value

A `MultiAssayExperiment` object that can store experiment and phenotype data

See Also

[MultiAssayExperiment-class](#)

Examples

```

## Run the example ExperimentList
example("ExperimentList")

## Create sample maps for each experiment
exprmap <- data.frame(
  primary = c("Jack", "Jill", "Barbara", "Bob"),
  colname = c("array1", "array2", "array3", "array4"),
  stringsAsFactors = FALSE)

methylmap <- data.frame(
  primary = c("Jack", "Jack", "Jill", "Barbara", "Bob"),
  colname = c("methyl1", "methyl2", "methyl3", "methyl4", "methyl5"),
  stringsAsFactors = FALSE)

rnamap <- data.frame(
  primary = c("Jack", "Jill", "Bob", "Barbara"),
  colname = c("samparray1", "samparray2", "samparray3", "samparray4"),
  stringsAsFactors = FALSE)

gistmap <- data.frame(
  primary = c("Jack", "Bob", "Jill"),
  colname = c("samp0", "samp1", "samp2"),
  stringsAsFactors = FALSE)

## Combine as a named list and convert to a DataFrame
maplist <- list(Affy = exprmap, Methyl450k = methylmap,
  RNASeqGene = rnamap, GISTIC = gistmap)

## Create a sampleMap
sampMap <- listToMap(maplist)
## Create an example phenotype data
colDat <- data.frame(sex = c("M", "F", "M", "F"), age = 38:41,
  row.names = c("Jack", "Jill", "Bob", "Barbara"))

## Create a MultiAssayExperiment instance
mae <- MultiAssayExperiment(experiments = Explist, colData = colDat,
  sampleMap = sampMap)

```

MultiAssayExperiment-class

An integrative multi-assay class for experiment data

Description

The `MultiAssayExperiment` class can be used to manage results of diverse assays on a collection of specimen. Currently, the class can handle assays that are organized instances of [SummarizedExperiment](#), [ExpressionSet](#), [matrix](#), [RaggedExperiment](#) (inherits from [GRangesList](#)), and [RangedVcfStack](#). Create new `MultiAssayExperiment` instances with the homonymous constructor, minimally with the argument [ExperimentList](#), potentially also with the arguments `colData` (see section below) and [sampleMap](#).

Usage

```
## S4 method for signature 'MultiAssayExperiment'
show(object)

## S4 method for signature 'MultiAssayExperiment'
length(x)

## S4 method for signature 'MultiAssayExperiment'
names(x)

## S4 method for signature 'MultiAssayExperiment'
updateObject(object, ...,
  verbose = FALSE)

## S4 method for signature 'MultiAssayExperiment'
dimnames(x)

## S4 method for signature 'MultiAssayExperiment'
c(x, ..., sampleMap = NULL,
  mapFrom = NULL)

## S4 method for signature 'MultiAssayExperiment'
assays(x, ..., withDimnames = TRUE)

## S4 method for signature 'MultiAssayExperiment,missing'
assay(x, i, ...)

## S4 method for signature 'MultiAssayExperiment,numeric'
assay(x, i, ...)

## S4 method for signature 'MultiAssayExperiment,character'
assay(x, i, ...)
```

Arguments

object	A MultiAssayExperiment object
x	A MultiAssayExperiment object
...	Additional arguments for supporting functions. See details.
verbose	logical (default FALSE) whether to print extra messages
sampleMap	c method: a sampleMap list or DataFrame to guide merge
mapFrom	Either a logical, character, or integer vector indicating the experiment(s) that have an identical colname order as the experiment input(s)
withDimnames	logical (default TRUE) whether to return dimension names included in the object
i	An integer or character scalar indicating the assay to return

Details

The dots (...) argument allows the user to specify additional arguments in several instances.

- subsetting [: additional arguments sent to [findOverlaps](#).

- `mergeReplicates`: used to specify arguments for the `simplify` functional argument
- `assay`: may contain `withDimnames`, which is forwarded to assays
- combining `c`: compatible `MultiAssayExperiment` classes passed on to the `ExperimentList` constructor, can be a list, `List`, or a series of named arguments. See the examples below.

Value

A `MultiAssayExperiment` object

Methods (by generic)

- `show`: Show method for a `MultiAssayExperiment`
- `length`: Get the length of `ExperimentList`
- `names`: Get the names of the `ExperimentList`
- `updateObject`: Update old serialized `MultiAssayExperiment` objects to new API
- `dimnames`: Get the dimension names for a `MultiAssayExperiment` object
- `c`: Add a supported data class to the `ExperimentList`
- `assays`: Obtain a `SimpleList` of assay data for all available experiments in the object
- `assay`: Convenience function for extracting the assay of the first element (default) in the `ExperimentList`. A numeric or character index can also be provided

Slots

`ExperimentList` A `ExperimentList` class object for each assay dataset
`colData` A `DataFrame` of all clinical/specimen data available across experiments
`sampleMap` A `DataFrame` of translatable identifiers of samples and participants
`metadata` Additional data describing the `MultiAssayExperiment` object
`drops` A metadata list of dropped information

colData

The `colData` slot is a collection of primary specimen data valid across all experiments. This slot is strictly of class `DataFrame` but arguments for the constructor function allow arguments to be of class `data.frame` and subsequently coerced.

ExperimentList

The `ExperimentList` slot is designed to contain results from each experiment/assay. It contains a `SimpleList`.

sampleMap

The `sampleMap` contains a `DataFrame` of translatable identifiers of samples and participants or biological units. Standard column names of the `sampleMap` are "assay", "primary", and "colname".

See Also

[MultiAssayExperiment-methods](#) for slot modifying methods [MultiAssayExperiment API](#)

Examples

```

example("MultiAssayExperiment")

## Subsetting
# Rows (i) Rows/Features in each experiment
mae[1, , ]
mae[c(TRUE, FALSE), , ]

# Columns (j) Rows in colData
mae[, rownames(colData(mae))[3:2], ]

# Assays (k)
mae[, , "Affy"]

## Complete cases (returns logical vector)
completes <- complete.cases(mae)
compMAE <- mae[, completes, ]
compMAE
colData(compMAE)

example("MultiAssayExperiment")

## Add an experiment
test1 <- mae[[1L]]
colnames(test1) <- rownames(colData(mae))

## Combine current MultiAssayExperiment with additional experiment
## (no sampleMap)
c(mae, newExperiment = test1)

test2 <- mae[[1L]]
c(mae, newExp = test2, mapFrom = 3L)

```

MultiAssayExperiment-helpers

A group of helper functions for manipulating and cleaning a MultiAssayExperiment

Description

A set of helper functions were created to help clean and manipulate a MultiAssayExperiment object. intersectRows also works for ExperimentList objects.

- complete.cases: Returns a logical vector corresponding to 'colData' rows that have data across all experiments
- isEmpty: Returns a logical TRUE value for zero length MultiAssayExperiment objects
- intersectRows: Takes all common rows across experiments, excludes experiments with empty rownames
- intersectColumns: A wrapper for complete.cases to return a MultiAssayExperiment with only those biological units that have measurements across all experiments

- replicated: A function that identifies multiple samples that originate from a single biological unit within each assay
- anyReplicated: Displays which assays have replicate measurements
- mergeReplicates: A function that combines replicated / repeated measurements across all experiments and is guided by the replicated return value
- longFormat: A MultiAssayExperiment method that returns a small and skinny [DataFrame](#). The colDataCols arguments allows the user to append colData columns to the data.
- wideFormat: A function to return a wide [DataFrame](#) where each row represents an observation. Optional colDataCols can be added when using a MultiAssayExperiment.
- hasRowRanges: A function that identifies ExperimentList elements that have a [rowRanges](#) method
- duplicated: (Deprecated) Returns a 'list' of 'LogicalList's that indicate what measurements originate from the same biological unit

Usage

```
## S4 method for signature 'MultiAssayExperiment'
complete.cases(...)

## S4 method for signature 'MultiAssayExperiment'
isEmpty(x)

intersectRows(x)

intersectColumns(x)

replicated(x)

## S4 method for signature 'MultiAssayExperiment'
replicated(x)

anyReplicated(x)

## S4 method for signature 'MultiAssayExperiment'
anyReplicated(x)

mergeReplicates(x, replicates = list(), simplify = BiocGenerics::mean,
  ...)

## S4 method for signature 'MultiAssayExperiment'
mergeReplicates(x,
  replicates = replicated(x), simplify = BiocGenerics::mean, ...)

## S4 method for signature 'ANY'
mergeReplicates(x, replicates = list(),
  simplify = BiocGenerics::mean, ...)

longFormat(object, colDataCols = NULL, i = 1L)

wideFormat(object, colDataCols = NULL, check.names = TRUE,
  collapse = "_", i = 1L)
```

```

hasRowRanges(x)

## S4 method for signature 'MultiAssayExperiment'
hasRowRanges(x)

## S4 method for signature 'ExperimentList'
hasRowRanges(x)

## S4 method for signature 'MultiAssayExperiment'
duplicated(x, incomparables = FALSE,
  ...)

```

Arguments

...	Additional arguments. See details for more information.
x	A MultiAssayExperiment or ExperimentList
replicates	A list of LogicalLists indicating multiple / duplicate entries for each biological unit per assay, see replicated (default replicated(x)).
simplify	A function for merging repeat measurements in experiments as indicated by the replicated method for MultiAssayExperiment
object	Any supported class object
colDataCols	A character, logical, or numeric index for colData columns to be included
i	The assay indicator for SummarizedExperiment objects (default 1L)
check.names	(logical default TRUE) Column names of the output DataFrame will be checked for syntactic validity and made unique, if necessary
collapse	(character default "_") A single string delimiter for output column names. In wideFormat, experiments and rownames (and when replicate samples are present, colnames) are separated by this delimiter
incomparables	unused argument

Details

The replicated function finds replicate measurements in each assay and returns a list of [LogicalLists](#). Each element in a single [LogicalList](#) corresponds to a biological or *primary* unit as in the sampleMap. Below is a small graphic for one particular biological unit in one assay, where the logical vector corresponds to the number of measurements/samples in the assay:

```

>      replicated(MultiAssayExperiment)
(list str)      '-- $ AssayName
(LogicalList str)  '-- [[ "Biological Unit" ]]
Replicated if sum(...) > 1      '-- TRUE TRUE FALSE FALSE

```

anyReplicated determines if any of the assays have at least one replicate. *Note.* These methods are not available for the ExperimentList class due to a missing sampleMap structure (by design).

The mergeReplicates function is a house-keeping method for a MultiAssayExperiment where only complete.cases are returned, replicate measurements are averaged (by default), and columns are aligned by the row order in colData. Additional arguments can be passed on to the simplify function.

The `mergeReplicates` "ANY" method consolidates duplicate measurements for rectangular data structures, returns object of the same class (endomorph). The ellipsis or `...` argument allows the user to provide additional arguments to the `simplify` functional argument.

The `longFormat` "ANY" class method, works with classes such as `ExpressionSet` and `SummarizedExperiment` as well as `matrix` to provide a consistent long and skinny `DataFrame`.

The `hasRowRanges` method identifies assays that support a `rowRanges` method *and* return a `GRanges` object.

Deprecated: For the `anyDuplicated` and `duplicated` functions, the `incomparables` and ellipsis `...` arguments are not used. Neither `duplicated` nor `anyDuplicated` is supported for `ExperimentList` due to an unavailable `sampleMap`.

mergeReplicates

The `mergeReplicates` function makes use of the output from `replicated` which will point out the duplicate measurements by biological unit in the `MultiAssayExperiment`. This function will return a `MultiAssayExperiment` with merged replicates. Additional arguments can be provided to the `simplify` argument via the ellipsis (`...`).

longFormat

The `longFormat` method takes data from the `ExperimentList` in a `MultiAssayExperiment` and returns a uniform `DataFrame`. The resulting `DataFrame` has columns indicating primary, rowname, colname and value. This method can optionally include `colData` columns with the `colDataCols` argument (`MultiAssayExperiment` method only). The `i` argument allows the user to specify the assay value in a `SummarizedExperiment`. It directly relates to the `i` argument in the `assay` method.

wideFormat

The `wideFormat` function returns standardized wide `DataFrame` where each row represents a biological unit as in the `colData`. Depending on the data and setup, biological units can be patients, tumors, specimens, etc. Optionally, `colData` columns can be added to the wide data output (see the `colDataCols` argument). Metadata columns are generated based on the names produced in the wide format `DataFrame`. These can be accessed via the `mcols` function. See the `Arguments` and `longFormat` sections for argument descriptions.

hasRowRanges

The `hasRowRanges` method identifies assays with associated ranged row data by directly testing the method on the object. The result from the test must be a `GRanges` class object to satisfy the test.

MultiAssayExperiment-methods

Accessing/modifying slot information

Description

A set of accessor and setter generic functions to extract either the `sampleMap`, the `ExperimentList`, `colData`, or metadata slots of a `MultiAssayExperiment` object

Usage

```
## S4 method for signature 'MultiAssayExperiment'
sampleMap(x)

## S4 method for signature 'MultiAssayExperiment'
experiments(x)

## S4 method for signature 'MultiAssayExperiment'
colData(x, ...)

## S4 method for signature 'MultiAssayExperiment'
metadata(x)

## S4 replacement method for signature 'MultiAssayExperiment,DataFrame'
sampleMap(object) <- value

## S4 replacement method for signature 'MultiAssayExperiment,ExperimentList'
experiments(object) <- value

## S4 replacement method for signature 'MultiAssayExperiment,DataFrame'
colData(x) <- value

## S4 replacement method for signature 'MultiAssayExperiment'
metadata(x, ...) <- value

## S4 replacement method for signature 'MultiAssayExperiment'
x$name <- value

## S4 replacement method for signature 'MultiAssayExperiment'
names(x) <- value

## S4 method for signature 'MultiAssayExperiment'
x$name
```

Arguments

x	A MultiAssayExperiment object
...	Argument not in use
object	A MultiAssayExperiment object
value	See details.
name	A column in colData

Value

Accessors: Either a sampleMap, ExperimentList, or DataFrame object

Setters: A MultiAssayExperiment object

Accessors

Eponymous names for accessing MultiAssayExperiment slots with the exception of the [ExperimentList](#) accessor named experiments.

- colData: Access the colData slot
- sampleMap: Access the sampleMap slot
- experiments: Access the [ExperimentList](#) slot
- '[': Access the [ExperimentList](#) slot
- '\$': Access a column in colData

Setters

Setter method values (i.e., 'function(x) <- value'):

- experiments<-: An [ExperimentList](#) object containing experiment data of supported classes
- sampleMap<-: A [DataFrame](#) object relating samples to biological units and assays
- colData<-: A [DataFrame](#) object describing the biological units
- metadata<-: A list object of metadata
- '['<-: Equivalent to the experiments<- setter method for convenience
- '\$<-': A vector to replace the indicated column in colData

Examples

```
## Load example MultiAssayExperiment
example(MultiAssayExperiment)

## Access the sampleMap
sampleMap(mae)

## Replacement method for a MultiAssayExperiment sampleMap
sampleMap(mae) <- S4Vectors::DataFrame()

## Access the ExperimentList
experiments(mae)

## Replace with an empty ExperimentList
experiments(mae) <- ExperimentList()

## Access the metadata
metadata(mae)

## Replace metadata with a list
metadata(mae) <- list(runDate =
  format(Sys.time(), "%B %d, %Y"))

## Access the colData
colData(mae)

## Access a column in colData
mae$age

## Replace a column in colData
mae$age <- mae$age + 1
```

```
prepMultiAssay      Prepare a MultiAssayExperiment instance
```

Description

The purpose of this helper function is to facilitate the creation of a `MultiAssayExperiment` object by detecting any inconsistencies with all types of names in either the `ExperimentList`, the `colData`, or `sampleMap`.

Usage

```
prepMultiAssay(ExperimentList, colData, sampleMap, ...)
```

Arguments

`ExperimentList` A list of all combined experiments

`colData` A `DataFrame` of the phenotype data for all participants

`sampleMap` A `DataFrame` of sample identifiers, assay samples, and assay names

`...` Optional arguments for the `MultiAssayExperiment` constructor function such as metadata and drops.

Value

A list containing all the essential components of a `MultiAssayExperiment` as well as a "drops" metadata element that indicates non-matched names. The names of the resulting list correspond to the arguments of the `MultiAssayExperiment` constructor function.

Checks

The `prepMultiAssay` function checks that all columns in the `sampleMap` are character.

It checks that all names and lengths match in both the `ExperimentList` and in the unique assay names of the `sampleMap`.

If `ExperimentList` names and assay names only differ by case and are not duplicated, the function will standardize all names to lowercase.

If names cannot be matched between the `colname` column of the `sampleMap` and the `colnames` of the `ExperimentList`, those unmatched will be dropped and found in the "drops" element of the resulting list.

Names in the "primary" column of the `sampleMap`, will be matched to those in the `colData`. Unmatched "primary" column rows will be dropped from the `sampleMap`. Suggestions for name fixes in either the `ExperimentList` or `colnames` will be made when necessary.

Examples

```
## Run example
example("MultiAssayExperiment")

## Check if there are any inconsistencies within the different names
preparedMAE <- prepMultiAssay(ExpList, colDat, sampMap)

## Results in a list of components for the MultiAssayExperiment constructor
```

```
## function
MultiAssayExperiment(preparedMAE$experiments, preparedMAE$colData,
preparedMAE$sampleMap)

## Alternatively, use the do.call function
do.call(MultiAssayExperiment, preparedMAE)
```

reexports

Objects exported from other packages

Description

These objects are imported from other packages. Click on the function name to see their documentation.

- S4Vectors: [DataFrame](#)

Examples

```
DataFrame()
```

subsetBy

Subsetting a MultiAssayExperiment object

Description

A set of functions for extracting and dividing a MultiAssayExperiment

Usage

```
subsetByRow(x, y, ...)
```

```
subsetByColData(x, y)
```

```
subsetByColumn(x, y)
```

```
subsetByAssay(x, y)
```

```
## S4 method for signature 'ExperimentList,ANY'
subsetByRow(x, y, ...)
```

```
## S4 method for signature 'ExperimentList,list'
subsetByRow(x, y)
```

```
## S4 method for signature 'ExperimentList,List'
subsetByRow(x, y)
```

```
## S4 method for signature 'ExperimentList,logical'
```

```

subsetByRow(x, y)

## S4 method for signature 'ExperimentList,list'
subsetByColumn(x, y)

## S4 method for signature 'ExperimentList,List'
subsetByColumn(x, y)

## S4 method for signature 'ExperimentList,logical'
subsetByColumn(x, y)

## S4 method for signature 'ExperimentList'
subsetByAssay(x, y)

## S4 method for signature 'MultiAssayExperiment,ANY'
subsetByColData(x, y)

## S4 method for signature 'MultiAssayExperiment,character'
subsetByColData(x, y)

## S4 method for signature 'MultiAssayExperiment,ANY'
subsetByRow(x, y, ...)

## S4 method for signature 'MultiAssayExperiment,ANY'
subsetByColumn(x, y)

## S4 method for signature 'MultiAssayExperiment'
subsetByAssay(x, y)

## S4 method for signature 'MultiAssayExperiment,ANY,ANY,ANY'
x[i, j, k, ...,
  drop = TRUE]

## S4 method for signature 'MultiAssayExperiment,ANY,ANY'
x[[i, j, ...]]

## S4 replacement method for signature 'MultiAssayExperiment,ANY,ANY'
x[[i, j, ...]] <- value

```

Arguments

x	A MultiAssayExperiment or ExperimentList
y	Any argument used for subsetting, can be a character, logical, integer, list or List vector
...	Additional arguments passed on to lower level functions.
i	Either a character, integer, logical or GRanges object for subsetting by rows
j	Either a character, logical, or numeric vector for subsetting by colData rows. See details for more information.
k	Either a character, logical, or numeric vector for subsetting by assays
drop	logical (default TRUE) whether to drop empty assay elements in the ExperimentList

value An assay compatible with the MultiAssayExperiment API

Details

Subsetting a MultiAssayExperiment by the **j** index can yield a call to either subsetByColData or subsetByColumn. For vector inputs, the subset will be applied to the colData rows. For List-type inputs, the List will be applied to each of the elements in the ExperimentList. The order of the subsetting elements in the List must match that of the ExperimentList in the MultiAssayExperiment.

- subsetByColData: Select biological units by vector input types
- subsetByColumn: Select observations by assay or for each assay
- subsetByRow: Select rows by assay or for each assay
- subsetByAssay: Select experiments

Examples

```
## Load the example MultiAssayExperiment
example("MultiAssayExperiment")

## Using experiment names
subsetByAssay(mae, "Affy")

## Using numeric indices
subsetByAssay(mae, 1:2)

## Using a logical vector
subsetByAssay(mae, c(TRUE, FALSE, TRUE))

## Subset by character vector (Jack)
subsetByColData(mae, "Jack")

## Subset by numeric index of colData rows (Jack and Bob)
subsetByColData(mae, c(1, 3))

## Subset by logical indicator of colData rows (Jack and Jill)
subsetByColData(mae, c(TRUE, TRUE, FALSE, FALSE))

subsetByColumn(mae, list(Affy = 1:2,
  Methyl450k = c(3,5,2), RNASeqGene = 2:4, GISTIC = 1))

subsetWith <- S4Vectors::mendoapply(`[,`, colnames(mae),
  MoreArgs = list(1:2))
subsetByColumn(mae, subsetWith)

## Use a GRanges object to subset rows where ranged data present
egr <- GenomicRanges::GRanges(seqnames = "chr2",
  IRanges::IRanges(start = 11, end = 13), strand = "-")
subsetByRow(mae, egr)

## Use a logical vector (recycling used)
subsetByRow(mae, c(TRUE, FALSE))

## Use a character vector
subsetByRow(mae, "ENST00000355076")
```

upsetSamples	<i>Create a generalized Venn Diagram analog for sample membership in multiple assays, using the upset algorithm in UpSetR</i>
--------------	---

Description

Create a generalized Venn Diagram analog for sample membership in multiple assays, using the upset algorithm in UpSetR

Usage

```
upsetSamples(MultiAssayExperiment, nsets = length(MultiAssayExperiment),
             nintersects = 24, order.by = "freq", nameFilter = force,
             check.names = FALSE, ...)
```

Arguments

MultiAssayExperiment	instance of MultiAssayExperiment-class
nsets	integer number of sets to analyze
nintersects	Number of intersections to plot. If set to NA, all intersections will be plotted.
order.by	How the intersections in the matrix should be ordered by. Options include frequency (entered as "freq"), degree, or both in any order.
nameFilter	function, defaulting to force, to manipulate colnames of incidence matrix
check.names	logical(1) used when incidence matrix is coerced to data.frame for use in UpSetR::upset
...	parameters passed to upset

Value

Produces a visualization of set intersections using the UpSet matrix design

Note

This function is intended to provide convenient visualization of assay availability configurations in MultiAssayExperiment instances. The [upset](#) function requires data.frame input and has many parameters to tune appearance of the result. Assay name handling is important for interpretability, and the nameFilter parameter may be useful to simplify resulting outputs.

Author(s)

Vincent J Carey

Examples

```
data(miniACC)
upsetSamples(miniACC)
upsetSamples(miniACC, nameFilter = function(x) substr(x, 1, 5))
```


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