

Package ‘RaggedExperiment’

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Title Representation of Sparse Experiments and Assays Across Samples

Version 1.6.0

Description This package provides a flexible representation of copy number, mutation, and other data that fit into the ragged array schema for genomic location data. The basic representation of such data provides a rectangular flat table interface to the user with range information in the rows and samples/specimen in the columns.

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biocViews Infrastructure, DataRepresentation

BugReports <https://github.com/Bioconductor/RaggedExperiment/issues>

VignetteBuilder knitr

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RaggedExperiment-package

RaggedExperiment: Range-based data representation package

Description

[RaggedExperiment](#) allows the user to represent, copy number, mutation, and other types of range-based data formats where optional information about samples can be provided. At the backbone of this package is the [GRangesList](#) class. The [RaggedExperiment](#) class uses this representation and presents the data in a couple of different ways:

- [rowRanges](#)
- [colData](#)

The [rowRanges](#) method will return the internal [GRangesList](#) representation of the dataset. A distinction between the [SummarizedExperiment](#) and the [RaggedExperiment](#) classes is that the [RaggedExperiment](#) class allows for ragged ranges, meaning that there may be a different number of ranges or rows per sample.

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See Also

Useful links:

- Report bugs at <https://github.com/Bioconductor/RaggedExperiment/issues>

assay-functions

Create simplified representation of ragged assay data.

Description

These methods transform `assay()` from the default (i.e., `sparseAssay()`) representation to various forms of more dense representation. `compactAssay()` collapses identical ranges across samples into a single row. `disjoinAssay()` creates disjoint (non-overlapping) regions, simplifies values within each sample in a user-specified manner, and returns a matrix of disjoint regions x samples.

This method transforms `assay()` from the default (i.e., `sparseAssay()`) representation to a reduced representation summarizing each original range overlapping ranges in query. Reduction in each cell can be tailored to individual needs using the `simplifyReduce` functional argument.

Usage

```

sparseAssay(x, i = 1, withDimnames = TRUE, background = NA_integer_)

compactAssay(x, i = 1, withDimnames = TRUE, background = NA_integer_)

disjoinAssay(x, simplifyDisjoin, i = 1, withDimnames = TRUE,
             background = NA_integer_)

qreduceAssay(x, query, simplifyReduce, i = 1, withDimnames = TRUE,
             background = NA_integer_)

```

Arguments

x A `RaggedExperiment` object

i `integer(1)` or `character(1)` name of assay to be transformed.

withDimnames `logical(1)` include dimnames on the returned matrix. When there are no explicit rownames, these are manufactured with `as.character(rowRanges(x))`; rownames are always manufactured for `compactAssay()` and `disjoinAssay()`.

background A value (default NA) for the returned matrix after *Assay operations

simplifyDisjoin

A function / functional operating on a *List, where the elements of the list are all within-sample assay values from ranges overlapping each disjoint range. For instance, to use the `simplifyDisjoin=mean` of overlapping ranges, where ranges are characterized by integer-valued scores, the entries are calculated as

```

              a
original: |-----|
              b
          |-----|

          a  a, b  b
disjoint: |----|-----|---|

values <- IntegerList(a, c(a, b), b)
simplifyDisjoin(values)

```

query GRanges providing regions over which reduction is to occur.

simplifyReduce A function / functional accepting arguments `score`, `range`, and `qrange`:

- `score` A *List, where each list element corresponds to a cell in the matrix to be returned by `qreduceAssay`. Vector elements correspond to ranges overlapping query. The *List objects support many vectorized mathematical operations, so `simplifyReduce` can be implemented efficiently.
- `range` A GRangesList instance, 'parallel' to `score`. Each element of the list corresponds to a cell in the matrix to be returned by `qreduceAssay`. Each range in the element corresponds to the range for which the score element applies.
- `qrange` A GRanges instance with the same length as `score`, providing the query range window to which the corresponding scores apply.

Value

`sparseAssay()`: A matrix() with dimensions `dim(x)`. Elements contain the assay value for the *i*th range and *j*th sample.

`compactAssay()`: Samples with identical range are placed in the same row. Non-disjoint ranges are NOT collapsed.

`disjoinAssay()`: A matrix with number of rows equal to number of disjoint ranges across all samples. Elements of the matrix are summarized by applying `simplifyDisjoin()` to assay values of overlapping ranges

`qreduceAssay()`: A matrix() with dimensions `length(query) × ncol(x)`. Elements contain assay values for the *i*th query range and *j*th sample, summarized according to the function `simplifyReduce`.

Examples

```
re4 <- RaggedExperiment(GRangesList(
  GRanges(c(A = "chr1:1-10:-", B = "chr1:8-14:-", C = "chr2:15-18:+"),
    score = 3:5),
  GRanges(c(D = "chr1:1-10:-", E = "chr2:11-18:+"), score = 1:2)
), colData = DataFrame(id = 1:2))

query <- GRanges(c("chr1:1-14:-", "chr2:11-18:+"))

weightedmean <- function(scores, ranges, qranges)
  ## weighted average score per query range
  sum(scores * width(ranges)) / sum(width(qranges))

qreduceAssay(re4, query, weightedmean)

## Not run:
## Extended example: non-silent mutations, summarized by genic
## region

suppressPackageStartupMessages({
  library(TxDb.Hsapiens.UCSC.hg19.knownGene)
  library(org.Hs.eg.db)
  library(GenomeInfoDb)
  library(MultiAssayExperiment)
})

## TCGA Multi-assay experiment to RaggedExperiment

url <- "http://s3.amazonaws.com/multiassayexperiments/accMAE0.rds"
## download.file(url, fl <- tempfile())
## fl <- "accMAE0.rds"
mae <- readRDS(fl)[, , c("RNASeq2GeneNorm", "CNASNP", "Mutations")]

## genomic coordinates

gn <- genes(TxDb.Hsapiens.UCSC.hg19.knownGene)
gn <- keepStandardChromosomes(granges(gn), pruning.mode="coarse")
seqlevelsStyle(gn) <- "NCBI"

## reduce mutations, marking any genomic range with non-silent
## mutation as FALSE

nonsilent <- function(scores, ranges, qranges)
```

```

    any(scores != "Silent")
re <- as(mae[["Mutations"]], "RaggedExperiment")
mutations <- qreduceAssay(re, gn, nonsilent, "Variant_Classification")

## reduce copy number

re <- as(mae[["CNASNP"]], "RaggedExperiment")
cn <- qreduceAssay(re, gn, weightedmean, "Segment_Mean")

## End(Not run)

```

RaggedExperiment-class

RaggedExperiment objects

Description

The `RaggedExperiment` class is a container for storing range-based data, including but not limited to copy number data, and mutation data. It can store a collection of `GRanges` objects, as it is derived from the `GenomicRangesList`.

Usage

```

RaggedExperiment(..., colData = DataFrame())

## S4 method for signature 'RaggedExperiment'
seqinfo(x)

## S4 replacement method for signature 'RaggedExperiment'
seqinfo(x, new2old = NULL,
  pruning.mode = c("error", "coarse", "fine", "tidy")) <- value

## S4 method for signature 'RaggedExperiment'
rowRanges(x, ...)

## S4 method for signature 'RaggedExperiment'
mcols(x, use.names = FALSE, ...)

## S4 replacement method for signature 'RaggedExperiment'
mcols(x, ...) <- value

## S4 method for signature 'RaggedExperiment'
rowData(x, use.names = TRUE, ...)

## S4 replacement method for signature 'RaggedExperiment'
rowData(x, ...) <- value

## S4 method for signature 'RaggedExperiment'
dim(x)

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

```

```

## S4 replacement method for signature 'RaggedExperiment,list'
dimnames(x) <- value

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

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

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

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

## S4 method for signature 'RaggedExperiment,ANY'
assay(x, i, ..., withDimnames = TRUE)

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

## S4 method for signature 'RaggedExperiment'
assayNames(x, ...)

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

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

## S4 method for signature 'RaggedExperiment,Vector'
overlapsAny(query, subject,
  maxgap = 0L, minoverlap = 1L, type = c("any", "start", "end",
  "within", "equal"), ...)

## S4 method for signature 'RaggedExperiment,Vector'
subsetByOverlaps(x, ranges,
  maxgap = -1L, minoverlap = 0L, type = c("any", "start", "end",
  "within", "equal"), invert = FALSE, ...)

```

Arguments

| | |
|---------|---|
| ... | Constructor: GRanges, list of GRanges, or GRangesList OR assay: Additional arguments for assay. See details for more information. |
| colData | A DataFrame describing samples. Length of rowRanges must equal the number of rows in colData |
| x | A RaggedExperiment object. |
| new2old | The new2old argument allows the user to rename, drop, add and/or reorder the "sequence levels" in x. new2old can be NULL or an integer vector with one element per row in Seqinfo object value (i.e. new2old and value must have the same length) describing |

how the "new" sequence levels should be mapped to the "old" sequence levels, that is, how the rows in `value` should be mapped to the rows in `seqinfo(x)`. The values in `new2old` must be ≥ 1 and $\leq \text{length}(\text{seqinfo}(x))$. NAs are allowed and indicate sequence levels that are being added. Old sequence levels that are not represented in `new2old` will be dropped, but this will fail if those levels are in use (e.g. if `x` is a `GRanges` object with ranges defined on those sequence levels) unless a pruning mode is specified via the `pruning.mode` argument (see below).

If `new2old=NULL`, then sequence levels can only be added to the existing ones, that is, `value` must have at least as many rows as `seqinfo(x)` (i.e. $\text{length}(\text{values}) \geq \text{length}(\text{seqinfo}(x))$) and also `seqlevels(values)[seq_len(length(seqlevels(x)))]` must be identical to `seqlevels(x)`.

`pruning.mode`

When some of the `seqlevels` to drop from `x` are in use (i.e. have ranges on them), the ranges on these sequences need to be removed before the `seqlevels` can be dropped. We call this *pruning*. The `pruning.mode` argument controls how to *prune* `x`. Four pruning modes are currently defined: "error", "coarse", "fine", and "tidy". "error" is the default. In this mode, no pruning is done and an error is raised. The other pruning modes do the following:

- "coarse": Remove the elements in `x` where the `seqlevels` to drop are in use. Typically reduces the length of `x`. Note that if `x` is a list-like object (e.g. `GRangesList`, `GAlignmentPairs`, or `GAlignmentsList`), then any list element in `x` where at least one of the sequence levels to drop is in use is *fully* removed. In other words, when `pruning.mode="coarse"`, the `seqlevels` setter will keep or remove *full list elements* and not try to change their content. This guarantees that the exact ranges (and their order) inside the individual list elements are preserved. This can be a desirable property when the list elements represent compound features like exons grouped by transcript (stored in a `GRangesList` object as returned by `exonsBy(, by="tx")`), or paired-end or fusion reads, etc...
- "fine": Supported on list-like objects only. Removes the ranges that are on the sequences to drop. This removal is done within each list element of the original object `x` and doesn't affect its length or the order of its list elements. In other words, the pruned object is guaranteed to be *parallel* to the original object.
- "tidy": Like the "fine" pruning above but also removes the list elements that become empty as the result of the pruning. Note that this pruning mode is particularly well suited on a `GRangesList` object that contains transcripts grouped by gene, as returned by `transcriptsBy(, by="gene")`. Finally note that, as a convenience, this pruning mode is supported on non list-like objects (e.g. `GRanges` or `GAlignments` objects) and, in this case, is equivalent to the "coarse" mode.

See the "B. DROP SEQLEVELS FROM A LIST-LIKE OBJECT" section in the examples below for an extensive illustration of these pruning modes.

| | |
|---------------------------|--|
| <code>value</code> | <ul style="list-style-type: none"> • <code>dimnames</code>: A list of dimension names • <code>mcols</code>: A <code>DataFrame</code> representing the assays |
| <code>use.names</code> | (logical default FALSE) whether to propagate rownames from the object to rownames of metadata <code>DataFrame</code> |
| <code>i</code> | logical(1), integer(1), or character(1) indicating the assay to be reported. For [, <code>i</code> can be any supported Vector object, e.g., <code>GRanges</code> . |
| <code>withDimnames</code> | logical (default TRUE) whether to use dimension names in the resulting object |

| | |
|------------|---|
| object | A RaggedExperiment object. |
| j | integer(), character(), or logical() index selecting columns from RaggedExperiment |
| drop | logical (default TRUE) whether to drop empty samples |
| query | A RaggedExperiment instance. |
| subject | <p>Each of them can be an IntegerRanges (e.g. IRanges, Views) or IntegerRangesList (e.g. IRangesList, ViewsList) derivative. In addition, if subject or ranges is an IntegerRanges object, query or x can be an integer vector to be converted to length-one ranges.</p> <p>If query (or x) is an IntegerRangesList object, then subject (or ranges) must also be an IntegerRangesList object.</p> <p>If both arguments are list-like objects with names, each list element from the 2nd argument is paired with the list element from the 1st argument with the matching name, if any. Otherwise, list elements are paired by position. The overlap is then computed between the pairs as described below.</p> <p>If subject is omitted, query is queried against itself. In this case, and only this case, the drop.self and drop.redundant arguments are allowed. By default, the result will contain hits for each range against itself, and if there is a hit from A to B, there is also a hit for B to A. If drop.self is TRUE, all self matches are dropped. If drop.redundant is TRUE, only one of A->B and B->A is returned.</p> |
| maxgap | <p>A single integer ≥ -1.</p> <p>If type is set to "any", maxgap is interpreted as the maximum <i>gap</i> that is allowed between 2 ranges for the ranges to be considered as overlapping. The <i>gap</i> between 2 ranges is the number of positions that separate them. The <i>gap</i> between 2 adjacent ranges is 0. By convention when one range has its start or end strictly inside the other (i.e. non-disjoint ranges), the <i>gap</i> is considered to be -1.</p> <p>If type is set to anything else, maxgap has a special meaning that depends on the particular type. See type below for more information.</p> |
| minoverlap | <p>A single non-negative integer.</p> <p>Only ranges with a minimum of minoverlap overlapping positions are considered to be overlapping.</p> <p>When type is "any", at least one of maxgap and minoverlap must be set to its default value.</p> |
| type | <p>By default, any overlap is accepted. By specifying the type parameter, one can select for specific types of overlap. The types correspond to operations in Allen's Interval Algebra (see references). If type is start or end, the intervals are required to have matching starts or ends, respectively. Specifying equal as the type returns the intersection of the start and end matches. If type is within, the query interval must be wholly contained within the subject interval. Note that all matches must additionally satisfy the minoverlap constraint described above.</p> <p>The maxgap parameter has special meaning with the special overlap types. For start, end, and equal, it specifies the maximum difference in the starts, ends or both, respectively. For within, it is the maximum amount by which the subject may be wider than the query. If maxgap is set to -1 (the default), it's replaced internally by 0.</p> |
| ranges | Each of them can be an IntegerRanges (e.g. IRanges , Views) or IntegerRangesList (e.g. IRangesList , ViewsList) derivative. In addition, if subject or ranges |

is an [IntegerRanges](#) object, query or x can be an integer vector to be converted to length-one ranges.

If query (or x) is an [IntegerRangesList](#) object, then subject (or ranges) must also be an [IntegerRangesList](#) object.

If both arguments are list-like objects with names, each list element from the 2nd argument is paired with the list element from the 1st argument with the matching name, if any. Otherwise, list elements are paired by position. The overlap is then computed between the pairs as described below.

If subject is omitted, query is queried against itself. In this case, and only this case, the `drop.self` and `drop.redundant` arguments are allowed. By default, the result will contain hits for each range against itself, and if there is a hit from A to B, there is also a hit for B to A. If `drop.self` is TRUE, all self matches are dropped. If `drop.redundant` is TRUE, only one of A->B and B->A is returned.

`invert` If TRUE, keep only the ranges in x that do *not* overlap ranges.

Value

constructor returns a `RaggedExperiment` object

`'rowRanges'` returns a [GRanges](#) object summarizing ranges corresponding to `assay()` rows.

`'mcols'` returns a [DataFrame](#) object of the metadata columns

`'assays'` returns a [SimpleList](#)

`'overlapsAny'` returns a logical vector of length equal to the number of rows in the query; TRUE when the copy number region overlaps the subject.

`'subsetByOverlaps'` returns a `RaggedExperiment` containing only copy number regions overlapping subject.

Methods (by generic)

- `seqinfo`: `seqinfo` accessor
- `seqinfo<-`: Replace `seqinfo` metadata of the ranges
- `rowRanges`: `rowRanges` accessor
- `mcols`: get the metadata columns of the ranges, rectangular representation of the `'assays'`
- `mcols<-`: set the metadata columns of the ranges corresponding to the assays
- `rowData`: get the `rowData` or metadata for the ranges
- `rowData<-`: set the `rowData` or metadata for the ranges
- `dim`: get dimensions (number of sample-specific row ranges by number of samples)
- `dimnames`: get row (sample-specific) range names and sample names
- `dimnames<-`: set row (sample-specific) range names and sample names
- `length`: get the length of row vectors in the object, similar to [SummarizedExperiment](#)
- `colData`: get column data
- `colData<-`: change the `colData`
- `assay`: assay missing method uses first metadata column
- `assay`: assay numeric method.
- `assays`: assays
- `assayNames`: names in each assay

- show: show method
- [: Subset a RaggedExperiment object
- overlapsAny: Determine whether copy number ranges defined by query overlap ranges of subject.
- subsetByOverlaps: Subset the RaggedExperiment to contain only copy number ranges overlapping ranges of subject.

Constructors

RaggedExperiment(..., colData=DataFrame()): Creates a RaggedExperiment object using multiple GRanges objects or a list of GRanges objects. Additional column data may be provided as a DataFrame object.

Accessors

In the following, 'x' represents a RaggedExperiment object:

rowRanges(x):

Get the ranged data. Value is a GenomicRanges object.

assays(x):

Get the assays. Value is a [SimpleList](#).

assay(x, i):

An alternative to assays(x)[[i]] to get the *i*th (default first) assay element.

mcols(x), mcols(x) <- value:

Get or set the metadata columns. For RaggedExperiment, the columns correspond to the assay *i*th elements.

rowData(x), rowData(x) <- value:

Get or set the row data. Value is a [DataFrame](#) object. Also corresponds to the mcols data.

Note for advanced users and developers. Both mcols and rowData setters may reduce the size of the internal RaggedExperiment data representation. Particularly after subsetting, the internal row index is modified and such setter operations will use the index to subset the data and reduce the "rows" of the internal data representation.

Subsetting

x[i, j]: Get ranges or elements (i and j, respectively) with optional metadata columns where i or j can be missing, an NA-free logical, numeric, or character vector.

Coercion

In the following, 'object' represents a RaggedExperiment object:

as(object, "GRangesList"):

Creates a [GRangesList](#) object from a RaggedExperiment.

as(from, "RaggedExperiment"):

Creates a RaggedExperiment object from a [GRangesList](#), or [GRanges](#) object.

Examples

```

## Create an empty RaggedExperiment instance
re0 <- RaggedExperiment()
re0

## Create a couple of GRanges objects with row ranges names
sample1 <- GRanges(
  c(a = "chr1:1-10:-", b = "chr1:11-18:+"),
  score = 1:2)
sample2 <- GRanges(
  c(c = "chr2:1-10:-", d = "chr2:11-18:+"),
  score = 3:4)

## Include column data
colDat <- DataFrame(id = 1:2)

## Create a RaggedExperiment object from a couple of GRanges
re1 <- RaggedExperiment(sample1=sample1, sample2=sample2, colData = colDat)
re1

## With list of GRanges
lgr <- list(sample1 = sample1, sample2 = sample2)

## Create a RaggedExperiment from a list of GRanges
re2 <- RaggedExperiment(lgr, colData = colDat)

gr1 <- GRangesList(sample1 = sample1, sample2 = sample2)

## Create a RaggedExperiment from a GRangesList
re3 <- RaggedExperiment(gr1, colData = colDat)

## Subset a RaggedExperiment
assay(re3[c(1, 3),])
subsetByOverlaps(re3, GRanges("chr1:1-5")) # by ranges

```

```
sparseSummarizedExperiment
```

Create SummarizedExperiment representations by transforming ragged assays to rectangular form.

Description

These methods transform RaggedExperiment objects to similar SummarizedExperiment objects. They do so by transforming assay data to more rectangular representations, following the rules outlined for similarly names transformations `sparseAssay()`, `compactAssay()`, `disjoinAssay()`, and `qreduceAssay()`. Because of the complexity of the transformation, it usually only makes sense transform RaggedExperiment objects with a single assay; this is currently enforced at time of coercion.

Usage

```
sparseSummarizedExperiment(x, i = 1, withDimnames = TRUE)
```

```
compactSummarizedExperiment(x, i = 1L, withDimnames = TRUE)

disjoinSummarizedExperiment(x, simplifyDisjoin, i = 1L,
  withDimnames = TRUE)

qreduceSummarizedExperiment(x, query, simplifyReduce, i = 1L,
  withDimnames = TRUE)
```

Arguments

| | |
|-----------------|---|
| x | RaggedExperiment |
| i | integer(1), character(1), or logical() selecting the assay to be transformed. |
| withDimnames | logical(1) default TRUE. propagate dimnames to SummarizedExperiment. |
| simplifyDisjoin | function of 1 argument, used to transform assays. See assay-functions . |
| query | GRanges provding regions over which reduction is occur. |
| simplifyReduce | function of 3 arguments used to transform assays. See assay-functions . |

Value

All functions return RangedSummarizedExperiment.

sparseSummarizedExperiment has rowRanges() identical to the row ranges of x, and assay() data as sparseAssay(). This is very space-inefficient representation of ragged data.

compactSummarizedExperiment has rowRanges() identical to the row ranges of x, and assay() data as compactAssay(). This is space-inefficient representation of ragged data when samples are primarily composed of different ranges.

disjoinSummarizedExperiment has rowRanges() identical to the disjoint row ranges of x, disjoint(rowRanges(x)), and assay() data as disjoinAssay().

qreduceSummarizedExperiment has rowRanges() identical to query, and assay() data as qreduceAssay().

Examples

```
x <- RaggedExperiment(GRangesList(
  GRanges(c("A:1-5", "A:4-6", "A:10-15"), score=1:3),
  GRanges(c("A:1-5", "B:1-3"), score=4:5)
))

## sparseSummarizedExperiment

sse <- sparseSummarizedExperiment(x)
assay(sse)
rowRanges(sse)

## compactSummarizedExperiment

cse <- compactSummarizedExperiment(x)
assay(cse)
rowRanges(cse)

## disjoinSummarizedExperiment
```

```
disjoinAssay(x, lengths)
dse <- disjoinSummarizedExperiment(x, lengths)
assay(dse)
rowRanges(dse)

## qreduceSummarizedExperiment

x <- RaggedExperiment(GRangesList(
  GRanges(c("A:1-3", "A:4-5", "A:10-15"), score=1:3),
  GRanges(c("A:4-5", "B:1-3"), score=4:5)
))
query <- GRanges(c("A:1-2", "A:4-5", "B:1-5"))

weightedmean <- function(scores, ranges, qranges)
  ## weighted average score per query range
  sum(scores * width(ranges)) / sum(width(ranges))

qreduceAssay(x, query, weightedmean)
qse <- qreduceSummarizedExperiment(x, query, weightedmean)
assay(qse)
rowRanges(qse)
```

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