

Package ‘extraChIPs’

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Title Additional functions for working with ChIP-Seq data

Description This package builds on existing tools and adds some simple but extremely useful capabilities for working with ChIP-Seq data. The focus is on detecting differential binding windows/regions. One set of functions focusses on set-operations retaining mcols for GRanges objects, whilst another group of functions are to aid visualisation of results. Coercion to tibble objects is also included.

License GPL-3

Encoding UTF-8

URL <https://github.com/steveped/extraChIPs>

BugReports <https://github.com/steveped/extraChIPs/issues>

Depends BiocParallel, R (>= 4.2.0), GenomicRanges, ggplot2 (>= 3.4.0), SummarizedExperiment, tibble

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 'importPeaks.R' 'makeConsensus.R' 'mapByFeature.R'
 'mergeByCol.R' 'mergeBySig.R' 'partitionRanges.R'
 'plotAssayDensities.R' 'plotAssayPCA.R' 'plotAssayRle.R'
 'plotHFGC.R' 'plotOverlaps.R' 'plotPie.R'
 'plotProfileHeatmap.R' 'plotSplitDonut.R' 'propOverlaps.R'
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extraChIPs-package *extraChIPs: A package for enabling and extending ChIP-Seq analysis*

Description

The package provides three categories of important functions: Range-based, Visualisation and Convenience functions, with most centred around GenomicRanges objects

Range-based Functions

Many of the range-based functions included in this package have a focus on retaining the `mcols` information whilst manipulating the ranges, such as `reduceMC()` which not only reduces the Ranges, but collapses the `mcols` into vectors or `IRanges::CompressedList` objects. Key function from this group are:

- `reduceMC()`, `setdiffMC()`, `intersectMC()`, `unionMC()`, `distinctMC()` and `chopMC()`
- `bestOverlap()` and `propOverlap()` provide simple output easily able to be added as a column within the `mcols` element
- `as_tibble()` coerces a GRanges object to a `tibble::tibble`.
- `colToRanges()` enables parsing of a single column to a GRanges object, setting all other columns as the `mcols` element.
- `stitchRanges()` merges nearby ranges setting barrier ranges which cannot be crossed when merging
- `partitionRanges()` break apart one set of ranges by another
- `dualFilter()` filters ranges from sliding windows using a guide set of reference ranges where signal is confidently expected
- `mergeByCol()` merges overlapping ranges, as produced by sliding windows
- `mapByFeature()` is able to map a set of GRanges to the most appropriate gene, using any optional combination of promoters, enhancers and HiC interactions
- `grlToSE()` takes selected columns from a GRangesList and sets them as assays within a `SummarizedExperiment::RangedSummarizedExperiment` object. Used for combining peak intensities or results across multiple ChIP targets.

Visualisation Functions

- `plotHFGC()` is a wrapper to Gviz plotting functions, able to take any combination of HiC, Features, Genes and Coverage (i.e. BigWig) and plot a specified range.
- `plotProfileHeatmap()` plots the average signal around a set of ranges, as prepared by `getProfileData()`
- `plotPie()` enables simple comparison across multiple annotation columns within a GRanges object.
- `plotAssayDensities()`, `plotAssayPCA()` and `plotAssayRle()` provide simple interfaces to plotting key values from a `SummarizedExperiment::RangedSummarizedExperiment`.

Convenience Functions

- `collapseGenes()` prints a vector of genes for an rmarkdown document, using italics.
- `importPeaks()` imports large numbers of broadPeak or narrowPeak files
- `voomWeightsFromCPM()` allows creation of an `limma::EList` object as would be created from counts by `limma::voom()`, but using `edgeR::cpm()` values as input.

Author(s)

Stephen Pederson

as_tibble

Convert to a tibble

Description

Convert multiple Genomic objects to tibbles

Usage

```
## S3 method for class 'DataFrame'
as_tibble(x, rangeAsChar = TRUE, ...)

## S3 method for class 'GenomicRanges'
as_tibble(x, rangeAsChar = TRUE, name = "range", ...)

## S3 method for class 'Seqinfo'
as_tibble(x, ...)

## S3 method for class 'GInteractions'
as_tibble(x, rangeAsChar = TRUE, suffix = c(".x", ".y"), ...)
```

Arguments

x	A Genomic Ranges or DataFrame object
rangeAsChar	Convert any GRanges element to a character vector
...	Passed to <code>tibble::as_tibble()</code>
name	Name of column to use for ranges. Ignored if rangeAsChar = FALSE
suffix	Suffix appended to column names for anchor1 and anchor2 of a GInteractions object. Only used if specifying rangeAsChar = FALSE

Details

Quick and dirty conversion into a tibble.

By default, GenomicRanges will be returned with the range as a character column called range and all mcols parsed as the remaining columns. Seqinfo information will be lost during coercion.

Given that names for ranges are considered as rownames in the mcols element, these can be simply parsed by setting rownames = "id" in the call to as_tibble()

When coercing a DataFrame, any Compressed/SimpleList columns will be coerced to S3 list columns. Any GRanges columns will be returned as a character column, losing any additional mcols from these secondary ranges

Defined as an S3 method for consistency with existing tidy methods

Value

A [tibble](#)

Examples

```
gr <- GRanges("chr1:1-10")
gr$p_value <- runif(1)
names(gr) <- "range1"
gr
as_tibble(gr)
as_tibble(gr, rownames = "id")
as_tibble(mcols(gr))
as_tibble(seqinfo(gr))

hic <- InteractionSet::GInteractions(gr, GRanges("chr1:201-210"))
hic$id <- "interaction1"
as_tibble(hic)
```

bestOverlap *Find the best overlap between GRanges*

Description

Find the best overlap between ranges

Usage

```
bestOverlap(x, y, ...)  
  
## S4 method for signature 'GRanges,GRanges'  
bestOverlap(  
  x,  
  y,  
  var = NULL,  
  ignore.strand = FALSE,  
  missing = NA_character_,  
  min_prop = 0.01,  
  ...  
)  
  
## S4 method for signature 'GRanges,GRangesList'  
bestOverlap(  
  x,  
  y,  
  ignore.strand = FALSE,  
  missing = NA_character_,  
  min_prop = 0.01,  
  ...  
)
```

Arguments

x	a GRanges object
y	a named GRangesList or GRanges object with mcol as reference category
...	Not used
var	The variable to use as the category. Not required if y is a GRangesList
ignore.strand	logical(1) Passed to findOverlaps
missing	Value to assign to ranges with no overlap
min_prop	Threshold below which overlaps are discarded

Details

This finds the category in the subject GRanges (y) which has the best overlap with the query GRanges (x). The aim is to produce a character vector for best classifying the query GRanges using an external set of features (e.g. promoters, enhancers etc). If the subject (y) is a GRanges object, the values in the specified column will be used as the category. If the subject (y) is a GRangesList, the names of the list will be used to provide the best match

Value

Character vector the same length as the supplied GRanges object

Examples

```
gr <- GRanges("chr1:1-10")
gr_cat <- GRanges(c("chr1:2-10", "chr1:5-10"))
gr_cat$category <- c("a", "b")
propOverlap(gr, gr_cat)
bestOverlap(gr, gr_cat, var = "category")

grl <- splitAsList(gr_cat, gr_cat$category)
lapply(grl, function(x) propOverlap(gr, x))
bestOverlap(gr, grl)
```

chopMC

Keep unique ranges and collapse mcols

Description

Keep unique ranges by 'chopping' mcols

Usage

```
chopMC(x, simplify = TRUE)
```

Arguments

x	A GenomicRanges object
simplify	logical(1)

Details

This function finds unique ranges and chops **all** mcols in a manner similar to [chop](#). Chopped columns will be returned as CompressedList columns, unless simplify = TRUE (the default). In this case, columns will be returned as vectors where possible.

Value

A GRanges object

Examples

```
gr <- GRanges(rep(c("chr1:1-10"), 2))
gr$id <- paste0("range", seq_along(gr))
gr$gene <- "gene1"
gr
chopMC(gr)
```

collapseGenes

*Collapse a vector of gene names***Description**

Collapse a vector of gene names

Usage

```
collapseGenes(
  x,
  sort = TRUE,
  dedup = TRUE,
  format = "_",
  sep = ", ",
  last = " and ",
  numeric = TRUE,
  width = Inf,
  ...
)
```

Arguments

x	character vector representing gene names
sort	logical(1) Should the names be sorted alphabetically
dedup	logical(1) Should duplicate names be removed
format	character string for markdown formatting of each element
sep	separator between vector elements
last	character string to place before the last element
numeric	logical(1) sort digits numerically, instead of as strings
width	The maximum width of the string before truncating to ...
...	passed to str_sort

Details

Convenience function to collapse a vector of gene names into a character/glue object of length 1. By default, symbols are deduplicated, sorted alpha-numerically and italicised with an underscore.

Value

a glue object

Examples

```
genes <- c("FOXP3", "BRCA1", "TP53")
collapseGenes(genes)
```

colToRanges

Coerce a column to a GRanges object

Description

Coerce a column to a GRanges object from a rectangular object

Usage

```
colToRanges(x, ...)

## S4 method for signature 'DataFrame'
colToRanges(x, var, seqinfo = NULL, ...)

## S4 method for signature 'GRanges'
colToRanges(x, var, ...)

## S4 method for signature 'data.frame'
colToRanges(x, var, seqinfo = NULL, ...)
```

Arguments

x	A data-frame or GRanges object containing the column to coerce
...	Used to pass arguments to lower-level functions
var	The name of the column to coerce
seqinfo	A seqinfo object to be applied to the new GRanges object. Ignored if the column is already a GRanges object

Details

Take a data.frame-like object and coerce one column to a GRanges object, setting the remainder as the mcols. A particularly useful application of this is when you have a GRanges object with one mcol being a secondary GRanges object.

Alternatively, if you have a data.frame with GRanges represented as a character column, this provides a simple method of coercion. In this case, no Seqinfo element will be applied to the GRanges element.

Value

A GenomicRanges object

Examples

```
set.seed(73)
x <- GRanges(c("chr1:1-10", "chr1:6-15", "chr1:51-60"))
seqinfo(x) <- Seqinfo("chr1", 60, FALSE, "Example")
df <- data.frame(logFC = rnorm(3), logCPM = rnorm(3,8), p = 10^-rexp(3))
mcols(x) <- df
gr <- mergeByCol(x, col = "logCPM", pval = "p")
colToRanges(gr, "keyval_range")
```

cytobands

Cytogenetic bands

Description

Cytogenetic bands for GRCh37/hg19 and GRCh38/hg38

Usage

```
data(grch37.cytobands)
```

```
data(grch38.cytobands)
```

Format

Cytogenetic bands for standard chromosomes from GRCh37, in the format required by [Ideogram-Track](#). A data.frame with 5 columns:

chrom Chromosome

chromStart Starting position for each cytogenetic band

chromEnd End position for each cytogenetic band

name Name for each band, e.g. p.36.33

gieStain Staining pattern

An object of class data.frame with 862 rows and 5 columns.

Source

<https://hgdownload.soe.ucsc.edu/goldenPath/hg19/database/cytoBand.txt.gz>

<https://hgdownload.soe.ucsc.edu/goldenPath/hg38/database/cytoBand.txt.gz>

Examples

```
data(grch37.cytobands)
head(grch37.cytobands)
```

```
data(grch38.cytobands)
head(grch38.cytobands)
```

distinctMC*Keep distinct ranges and mcols*

Description

Keep distinct ranges by including mcols

Usage

```
distinctMC(x, ..., .keep_all = FALSE)
```

Arguments

x	A GenomicRanges object
...	<data-masking> Passed to distinct
.keep_all	If TRUE, keep all columns in x

Details

Wrapper to [distinct](#) for GRanges objects. Finds unique ranges and mcols in combination and retains only the distinct combinations, in keeping with the `dplyr` function.

Will default to `unique(granges(x))` if no columns are provided

Value

A GRanges object

Examples

```
gr <- GRanges(rep(c("chr1:1-10"), 2))
gr$id <- paste0("range", seq_along(gr))
gr$gene <- "gene1"
gr
distinctMC(gr)
distinctMC(gr, gene)
distinctMC(gr, gene, .keep_all = TRUE)
```

dualFilter

*Apply two filters to sliding windows***Description**

Apply two filters to counts generated using sliding windows

Usage

```
dualFilter(
  x,
  bg,
  ref,
  q = 0.5,
  logCPM = TRUE,
  keep.totals = TRUE,
  BPPARAM = bpparam()
)
```

Arguments

x	RangedSummarizedExperiment containing sample counts
bg	RangedSummarizedExperiment containing background/input counts
ref	GRanges object containing ranges where signal is expected
q	The upper percentile of the reference ranges expected to be returned when tuning the filtering criteria
logCPM	logical(1) Add a logCPM assay to the returned data
keep.totals	logical(1) Keep the original library sizes or replace using only the retained windows
BPPARAM	Settings for running in parallel

Details

This function will take sliding (or tiling) windows for its input as a [RangedSummarizedExperiment](#) object. The dual strategy of applying [filterWindowsControl](#) and [filterWindowsProportion](#) will then be applied. A set of reference ranges for which signal is expected is used to refine the filtering criteria.

Cutoff values are found for both signal relative to input and overall signal, such that the $100 \cdot q\%$ of the (sliding) windows which overlap a reference range will be returned, along with any others which match the dual filtering criteria. In general, higher values of q will return more windows as those with weak signal and a marginal overlap with a reference range will be returned. Lower values will ensure that fewer windows, generally with the strongest signal, are retained. Cutoff values for both criteria are added to the metadata element of the returned object.

Please note that the any `.bam` files referred to in the supplied objects **must** be accessible to this function. It will not run on a separate machine or file structure to that which the original sliding windows were prepared. Please see the `example/vignette` for runnable code.

Value

A [RangedSummarizedExperiment](#) which is a filtered subset of the original object. If requested the assay "logCPM" will be added (TRUE by default)

Examples

```
## Taken from the differential_binding vignette
library(tidyverse)
library(Rsamtools)
library(csaw)
library(BiocParallel)
library(rtracklayer)
## For this function we need a set of counts using sliding windows and the
## original BamFiles from which they were taken
## First we'll set up the bam file list
bfl <- system.file(
  "extdata", "bam", c("ex1.bam", "ex2.bam", "input.bam"), package = "extraChIPs"
) %>%
  BamFileList() %>%
  setNames(c("ex1", "ex2", "input"))

## Then define the readParam settings for csaw::readParam()
rp <- readParam(
  pe = "none",
  dedup = TRUE,
  restrict = "chr10"
)

## Now we can form our sliding window object with the counts.
wincounts <- windowCounts(
  bam.files = bfl,
  spacing = 60,
  width = 180,
  ext = 200,
  filter = 1,
  param = rp
)

## As this is a subset of reads, add the initial library sizes for accuracy
## Note that this step is not normally required
wincounts$totals <- c(964076L, 989543L, 1172179L)

## We should also update the metadata for our counts
wincounts$sample <- colnames(wincounts)
wincounts$treat <- as.factor(c("ctrl", "treat", NA))
colData(wincounts)

## The function dualFilter requires a set of peaks which will guide the
## filtering step. This indicate where genuine signal is likely to be found
## and will perform the filtering based on a) signal above the input, and
## b) The overall signal level, using the guide set of peaks to inform the
## cutoff values for inclusion
peaks <- import.bed(
```

```
    system.file("extdata", "peaks.bed.gz", package = "extraChIPs")
  )
  filtcounts <- dualFilter(
    x = wincounts[, !is.na(wincounts$treat)],
    bg = wincounts[, is.na(wincounts$treat)],
    ref = peaks,
    q = 0.8 # Better to use q = 0.5 on real data
  )
```

ex_datasets

Datasets for an example region

Description

Various example datasets for demonstrating visualisation strategies. Generation of all datasets is documented in `system.file("script/ex_datasets.md", package = "extraChIPs")`

ex_genes Simple GRanges object with complete ranges for each gene

ex_trans Exon & transcript level information prepared for plotting with Gviz or plotHFGC()

ex_prom Regions defined as promoters

ex_hic Example HiC interactions

Usage

`data(ex_trans)`

`data(ex_genes)`

`data(ex_prom)`

`data(ex_hic)`

Format

GRanges and GInteractions objects

All annotations are from GRCh37

An object of class GRanges of length 4.

An object of class GRanges of length 9.

An object of class GInteractions of length 1.

Examples

```
data(ex_trans)
```

```
ex_trans
```

getProfileData	<i>Get Profile Data surrounding specified ranges</i>
----------------	--

Description

Get coverage Profile Data surrounding specified ranges

Usage

```
getProfileData(x, gr, ...)  
  
## S4 method for signature 'BigWigFile,GenomicRanges'  
getProfileData(  
  x,  
  gr,  
  upstream = 2500,  
  downstream = upstream,  
  bins = 100,  
  mean_mode = "w0",  
  log = TRUE,  
  offset = 1,  
  ...  
)  
  
## S4 method for signature 'BigWigFileList,GenomicRanges'  
getProfileData(  
  x,  
  gr,  
  upstream = 2500,  
  downstream = upstream,  
  bins = 100,  
  mean_mode = "w0",  
  log = TRUE,  
  offset = 1,  
  BPPARAM = SerialParam(),  
  ...  
)  
  
## S4 method for signature 'character,GenomicRanges'  
getProfileData(  
  x,  
  gr,  
  upstream = 2500,  
  downstream = upstream,  
  bins = 100,  
  mean_mode = "w0",  
  log = TRUE,
```

```

    offset = 1,
    ...
)

```

Arguments

x	A BigWigFile or BigWiFileList
gr	A GRanges object
...	Passed to normalizeToMatrix
upstream	The distance to extend upstream from the centre of each range within gr
downstream	The distance to extend downstream from the centre of each range within gr
bins	The total number of bins to break the extended ranges into
mean_mode	The method used for calculating the score for each bin. See normalizeToMatrix for details
log	logical(1) Should the returned values be log2-transformed
offset	Value added to data if log-transforming. Ignored otherwise
BPPARAM	Passed internally to bplapply

Details

This will take all provided ranges and set as identical width ranges, extending by the specified amount both up and downstream of the centre of the provided ranges. By default, the ranges extensions are symmetrical and only the upstream range needs to be specified, however this parameterisation allows for non-symmetrical ranges to be generated.

These uniform width ranges will then be used to extract the value contained in the score field from one or more BigWigFiles. Uniform width ranges are then broken into bins of equal width and the average score found within each bin.

The binned profiles are returned as a DataFrameList called `profile_data` as a column within the resized GRanges object. Column names in each DataFrame are `score`, `position` and `bp`.

If passing a BigWigFileList, profiles will be obtained in series by default. To run in parallel pass a [MulticoreParam](#) object to the BPPARAM argument.

Value

GRanges or GrangesList with column `profile_data`, as described above

Examples

```

bw <- system.file("tests", "test.bw", package = "rtracklayer")
gr <- GRanges("chr2:1000")
pd <- getProfileData(bw, gr, upstream = 500, bins = 10)
pd
pd$profile_data

```

grlToSE	<i>Set columns from a GRangesList as Assays in a SummarizedExperiment</i>
---------	---

Description

Move one or more columns from a GRangesList elements into assays in a RangesSummarizedExperiment

Usage

```
grlToSE(x, ...)

## S4 method for signature 'GRangesList'
grlToSE(
  x,
  assayCols = c(),
  metaCols = c(),
  keyvals = c(),
  by = c("min", "max"),
  ...,
  ignore.strand = FALSE
)
```

Arguments

x	A GRangesList
...	Passed to reduce
assayCols	Columns to move to separate assays
metaCols	Columns to move to mcols within the rowRanges element
keyvals	The value to use when choosing representative values
by	How to choose by keyvals
ignore.strand	logical(1). Whether the strand of the input ranges should be ignored or not.

Details

Given a GRangesList which would commonly represent multiple samples, reduce any overlapping ranges into a consensus range, setting any metadata columns to be retained as separate assays. These columns may contain values such as coverage, p-values etc.

Additional columns can also be placed as rowData columns where the original values are better suited to information about the consensus range rather than the sample (or GRangesList element).

Only one value for each range will be retained, and these are chosen using the value provided as the keyvals, taking either the min or max value in this column as the representative range.

Value

A RangedSummarizedExperiment

Examples

```
a <- GRanges("chr1:1-10")
a$feature <- "Gene"
a$p <- 0.1
b <- GRanges(c("chr1:6-15", "chr1:15"))
b$feature <- c("Gene", "Promoter")
b$p <- c(0.5, 0.01)
grl <- GRangesList(a = a, b = b)
grl
se <- grlToSE(
  grl, assayCols = "p", metaCols = "feature", keyvals = "p", by = "min"
)
assay(se, "p")
rowRanges(se)
```

importPeaks

Import peaks

Description

Import peaks in narrowPeak or broadPeak format

Usage

```
importPeaks(
  x,
  type = c("narrow", "broad"),
  blacklist,
  seqinfo,
  pruning.mode = c("coarse", "error"),
  sort = TRUE,
  setNames = TRUE,
  ...
)
```

Arguments

x	One or more files to be imported. All files must be of the same type, i.e. narrow or broad
type	The type of peaks to be imported
blacklist	A set of ranges to be excluded
seqinfo	A seqinfo object to be applied to the GRanges objects

pruning.mode	How to handle conflicts if supplying a seqinfo object. Defaults to pruning.mode = "coarse". Only "coarse" and "error" are implemented. See seqinfo .
sort	logical. Should the ranges be sorted during import
setNames	logical Set basename(x) as the name
...	passed to sort

Details

Peaks are imported from either narrowPeak or broadPeak format as GenomicRanges objects.

Value

A GRangesList

Examples

```
f1 <- system.file(
  c("extdata/ER_1.narrowPeak", "extdata/ER_2.narrowPeak"),
  package = "extraChIPs"
)
peaks <- importPeaks(f1)
peaks
```

makeConsensus	<i>Make a set of consensus peaks</i>
---------------	--------------------------------------

Description

Make a set of consensus peaks based on number of replicates

Usage

```
makeConsensus(
  x,
  p = 0,
  var = NULL,
  ignore.strand = TRUE,
  simplify = FALSE,
  ...
)
```

Arguments

x	A GRangesList
p	The minimum proportion of samples (i.e. elements of x) required for a peak to be retained in the output. By default all merged peaks will be returned
var	Additional columns in the mcols element to retain
ignore.strand, simplify, ...	Passed to reduceMC()

Details

This takes a list of GRanges objects and forms a set of consensus peaks using the minimum proportion of replicates specified

Value

GRanges object with mcols containing a logical vector for every element of x, along with the column n which adds all logical columns.

If any additional columns have been requested using var, these will be returned as CompressedList objects as produced by reduceMC().

See Also

[reduceMC](#)

Examples

```
a <- GRanges("chr1:11-20")
a$score <- 1
b <- GRanges(c("chr1:18-22", "chr1:1-5"))
b$score <- c(0.6, 0.3)
grl <- GRangesList(a = a, b = b)
makeConsensus(grl)
makeConsensus(grl, p = 1)
makeConsensus(grl, p = 1, var = "score")
```

mapByFeature

Map Genomic Ranges to genes using defined features

Description

Map Genomic Ranges to genes using defined regulatory features

Usage

```
mapByFeature(
  gr,
  genes,
  prom,
  enh,
  gi,
  cols = c("gene_id", "gene_name", "symbol"),
  gr2prom = 0,
  gr2enh = 0,
  gr2gi = 0,
  gr2gene = 1e+05,
  prom2gene = 0,
  enh2gene = 1e+05,
  gi2gene = 0,
  ...
)
```

Arguments

gr	GRanges object with query ranges to be mapped to genes
genes	GRanges object containing genes (or any other nominal feature) to be assigned
prom	GRanges object defining promoters
enh	GRanges object defining Enhancers
gi	GInteractions object defining interactions. Mappings from interactions to genes should be performed as a separate prior step.
cols	Column names to be assigned as mcols in the output. Columns must be minimally present in genes. If all requested columns are found in any of prom, enh or gi, these pre-existing mappings will be preferentially used. Any columns not found in utilised reference objects will be ignored.
gr2prom	The maximum permissible distance between a query range and any ranges defined as promoters
gr2enh	The maximum permissible distance between a query range and any ranges defined as enhancers
gr2gi	The maximum permissible distance between a query range and any ranges defined as GInteraction anchors
gr2gene	The maximum permissible distance between a query range and genes (for ranges not otherwise mapped)
prom2gene	The maximum permissible distance between a range provided in prom and a gene
enh2gene	The maximum permissible distance between a range provided in enh and a gene
gi2gene	The maximum permissible distance between a GInteractions anchor (provided in gi) and a gene
...	Passed to findOverlaps nad overlapsAny internally

Details

This function is able to utilise feature-level information and long-range interactions to enable better mapping of regions to genes. If provided, this essentially maps from ranges to genes using the regulatory features as a framework. The following sequential strategy is used:

1. Ranges overlapping a promoter are assigned to that gene
2. Ranges overlapping an enhancer are assigned to **all genes** within a specified distance
3. Ranges overlapping a long-range interaction are assigned to all genes connected by the interaction
4. Ranges with no gene assignment from the previous steps are assigned to *all overlapping genes* or the nearest gene within a specified distance

If information is missing for one of these steps, the algorithm will simply proceed to the next step. If no promoter, enhancer or interaction data is provided, all ranges will be simply mapped by step 4. Ranges can be mapped by any or all of the first three steps, but step 4 is mutually exclusive with the first 3 steps.

Distances between each set of features and the query range can be individually specified by modifying the `gr2prom`, `gr2enh`, `gr2gi` or `gr2gene` parameters. Distances between features and genes can also be set using the parameters `prom2gene`, `enh2gene` and `gi2gene`.

Additionally, if previously defined mappings are included with any of the `prom`, `enh` or `gi` objects, this will be used in preference to any obtained from the `genes` object.

Value

A GRanges object with added `mcols` as specified

Examples

```
## Define some genes
genes <- GRanges(c("chr1:2-10:*", "chr1:25-30:-", "chr1:31-40:+"))
genes$gene_id <- paste0("gene", seq_along(genes))
genes
## Add a promoter for each gene
prom <- promoters(genes, upstream = 1, downstream = 1)
prom
## Some ranges to map
gr <- GRanges(paste0("chr1:", seq(0, 60, by = 15)))
gr

## Map so that any gene within 25bp of the range is assigned
mapByFeature(gr, genes, gr2gene = 25)

## Now use promoters to be more accurate in the gene assignment
## Given that the first range overlaps the promoter of gene1, this is a
## more targetted approach. Similarly for the third range
mapByFeature(gr, genes, prom, gr2gene = 25)
```

mergeByCol	<i>Merge sliding windows using a specified column</i>
------------	---

Description

Merge sliding windows using a specified column

Usage

```
mergeByCol(x, ...)  
  
## S4 method for signature 'GenomicRanges'  
mergeByCol(  
  x,  
  df = NULL,  
  col,  
  by = c("max", "median", "mean", "min"),  
  logfc = "logFC",  
  pval = "P",  
  inc_cols,  
  p_adj_method = "fdr",  
  merge_within = 1L,  
  ignore_strand = TRUE,  
  ...  
)  
  
## S4 method for signature 'RangedSummarizedExperiment'  
mergeByCol(  
  x,  
  df = NULL,  
  col,  
  by = c("max", "median", "mean", "min"),  
  logfc = "logFC",  
  pval = "P",  
  inc_cols,  
  p_adj_method = "fdr",  
  merge_within = 1L,  
  ignore_strand = FALSE,  
  ...  
)
```

Arguments

x	A GenomicRanges or SummarizedExperiment object
...	Not used
df	A data.frame-like object containing the columns of interest. If not provided, any columns in the mcols() slot will be used.

col	The column to select as representative of the merged ranges
by	The method for selecting representative values
logfc	Column containing logFC values
pval	Column containing p-values
inc_cols	Any additional columns to return. Output will always include columns specified in the arguments col, logfc and pval. Note that values from any additional columns will correspond to the selected range returned in keyval_range
p_adj_method	Any of p.adjust.methods
merge_within	Merge any ranges within this distance
ignore_strand	Passed internally to reduce and findOverlaps

Details

This merges sliding windows using the values in a given column to select representative values for the subsequent merged windows. Values can be chosen from the specified column using any of `min()`, `max()`, `mean()` or `median()`, although `max()` is strongly recommended when specifying values like logCPM. Once a representative range is selected using the specified column, values from columns specified using `inc_cols` are also returned. In addition to these columns, the range from the representative window is returned in the `mcols` element as a `GRanges` object in the column `keyval_range`.

Merging windows using either the logFC or p-value columns is not implemented.

If adjusted p-values are requested an additional column names the same as the initial p-value, but tagged with the adjustment method, will be added. In addition, using the p-value from the selected window, the number of windows with lower p-values are counted by direction and returned in the final object. The selected window will always be counted as up/down regardless of significance as the p-value for this column is taken as the threshold. This is a not dissimilar approach to [cluster-direction](#).

If called on a `SummarizedExperiment` object, the function will be applied to the `rowRanges` element.

Value

A Genomic Ranges object

Examples

```
x <- GRanges(c("chr1:1-10", "chr1:6-15", "chr1:51-60"))
set.seed(1001)
df <- DataFrame(logFC = rnorm(3), logCPM = rnorm(3,8), p = rexp(3, 10))
mergeByCol(x, df, col = "logCPM", pval = "p")
mcols(x) <- df
x
mergeByCol(x, col = "logCPM", pval = "p")
```

mergeBySig	<i>Merge overlapping ranges based on p-values</i>
------------	---

Description

Merge overlapping windows using p-values from significance testing

Usage

```
mergeBySig(x, ...)  
  
## S4 method for signature 'GenomicRanges'  
mergeBySig(  
  x,  
  df = NULL,  
  logfc = "logFC",  
  pval = "P",  
  cpm = "logCPM",  
  inc_cols,  
  p_adj_method = "fdr",  
  alpha = 0.05,  
  method = c("combine", "best", "minimal"),  
  merge_within = 1L,  
  ignore_strand = TRUE,  
  ...  
)  
  
## S4 method for signature 'RangedSummarizedExperiment'  
mergeBySig(  
  x,  
  df = NULL,  
  logfc = "logFC",  
  pval = "P",  
  cpm = "logCPM",  
  inc_cols,  
  p_adj_method = "fdr",  
  alpha = 0.05,  
  method = c("combine", "best", "minimal"),  
  merge_within = 1L,  
  ignore_strand = TRUE,  
  ...  
)
```

Arguments

x	GenomicRanges object
...	Passed to all csaw functions being wrapped

<code>df</code>	data.frame with results of differential binding analysis performed using a sliding window strategy. If not provided, the columns in the <code>mcols()</code> element of <code>x</code> will be used
<code>logfc, pval, cpm</code>	Column names for the values holding window specific estimates of change in binding (<code>logfc</code>), overall signal intensity (<code>cpm</code>) and the significance from statistical testing (<code>pval</code>)
<code>inc_cols</code>	(Optional) Character vector of any additional columns in <code>df</code> to return
<code>p_adj_method</code>	One of <code>p.adjust.methods</code>
<code>alpha</code>	Significance threshold to apply during internal calculations
<code>method</code>	Shorthand versions for which <code>csaw</code> strategy to use for merging windows. Choose from 'combine' (combineTests), 'best' (getBestTest) or 'minimal' (minimalTests).
<code>merge_within</code>	Merge any non-overlapping windows within this distance
<code>ignore_strand</code>	Passed internally to reduce and findOverlaps

Details

When using sliding windows to test for differential signal, overlapping windows can be merged based on the significance of results. `mergeBySig()` is a wrapper to the functions [combineTests](#), [getBestTest](#) and [minimalTests](#), using each function's approach to finding a representative window. The returned object differs from those returned by the original functions in that the description of windows as 'up', 'down' or mixed is omitted and the genomic range corresponding to the representative window is also returned. Column names also correspond to those in the original object.

An additional column with adjusted p-values is returned. This column retains the same name as the original but with the suffix `'_*'` added where the p-value adjustment method is added after the underscore.

Value

A `GenomicRanges` object with overlapping ranges from the original object merged and representative values returned. The range corresponding to the representative values is also returned

Examples

```
x <- GRanges(c("chr1:1-10", "chr1:6-15", "chr1:51-60"))
set.seed(1001)
df <- DataFrame(logFC = rnorm(3), logCPM = rnorm(3,8), p = rexp(3, 10))
mcols(x) <- df
mergeBySig(x, pval = "p", method = "combine")
mergeBySig(x, pval = "p", method = "best")
mergeBySig(x, pval = "p", method = "min")
```

partitionRanges	<i>Partition a set of Genomic Ranges</i>
-----------------	--

Description

Partition a set of Genomic Ranges by another

Usage

```
partitionRanges(x, y, ...)

## S4 method for signature 'GRanges,GRanges'
partitionRanges(
  x,
  y,
  y_as_both = TRUE,
  ignore.strand = FALSE,
  simplify = TRUE,
  suffix = c(".x", ".y"),
  ...
)
```

Arguments

x, y	GenomicRanges objects
...	Not used
y_as_both	logical(1) If there are any unstranded regions in y, should these be assigned to both strands. If TRUE unstranded regions can be used to partition stranded regions
ignore.strand	If set to TRUE, then the strand of x and y is set to "*" prior to any computation.
simplify	Pass to chopMC and simplify mcols in the output
suffix	Added to any shared column names in the provided objects

Details

The query set of ranges can be broken in regions which strictly overlap a second set of ranges. The complete set of mcols from both initial objects will included in the set of partitioned ranges

Value

A GRanges object

Examples

```
x <- GRanges(c("chr1:1-10", "chr1:6-15"))
x$id <- paste0("range", seq_along(x))
x
y <- GRanges(c("chr1:2-5", "chr1:6-12"))
y$id <- paste0("range", seq_along(y))
y
partitionRanges(x, y)
```

plotAssayDensities *Plot Densities for any assay within a SummarizedExperiment*

Description

Plot Densities for any assay within a SummarizedExperiment

Usage

```
plotAssayDensities(x, ...)

## S4 method for signature 'SummarizedExperiment'
plotAssayDensities(
  x,
  assay = "counts",
  colour = NULL,
  linetype = NULL,
  group,
  trans = NULL,
  n_max = Inf,
  ...
)
```

Arguments

x	A SummarizedExperiment object
...	Passed to density
assay	An assay within x
colour	The column in colData to colour lines by. To remove any colours, set this argument to NULL
linetype	Any optional column in colData used to determine linetype
group	Used by geom_line . Defaults to the sample names but setting to NULL will over-write this and only groups specified by colour or linetype will be drawn
trans	character(1). Any transformative function to be applied to the data before calculating the density, e.g. trans = "log2"
n_max	Maximum number of points to use when calculating densities

Details

Uses ggplot2 to create a density plot for all samples within the selected assay

Value

A ggplot2 object. Scales and labels can be added using conventional ggplot2 syntax.

Examples

```
nrows <- 200; ncols <- 4
counts <- matrix(runif(nrows * ncols, 1, 1e4), nrows)
colnames(counts) <- paste0("Sample_", seq_len(ncols))
df <- DataFrame(treat = c("A", "A", "B", "B"))
se <- SummarizedExperiment(
  assays = SimpleList(counts = counts),
  colData = df
)
plotAssayDensities(se, colour = "treat")
plotAssayDensities(se, colour = "treat", group = NULL)
```

plotAssayPCA

Plot PCA For any assay within a SummarizedExperiment

Description

Plot PCA for any assay within a SummarizedExperiment object

Usage

```
plotAssayPCA(x, ...)

## S4 method for signature 'SummarizedExperiment'
plotAssayPCA(
  x,
  assay = "counts",
  colour = NULL,
  shape = NULL,
  label = NULL,
  show_points = TRUE,
  pc_x = 1,
  pc_y = 2,
  trans = NULL,
  n_max = Inf,
  ...
)
```

Arguments

x	An object containing an assay slot
...	Passed to geom_text
assay	The assay to perform PCA on
colour	The column name to be used for colours
shape	The column name to be used for determining the shape of points
label	The column name to be used for labels
show_points	logical(1). Display the points. If TRUE any labels will repel. If FALSE, labels will appear at the exact points
pc_x	numeric(1) The PC to plot on the x-axis
pc_y	numeric(1) The PC to plot on the y-axis
trans	character(1). Any transformative function to be applied to the data before performing the PCA, e.g. trans = "log2"
n_max	Subsample the data to this many points before performing PCA

Details

Uses ggplot2 to create a PCA plot for the selected assay. Any numerical transformation prior to performing the PCA can be specified using the trans argument

Value

A ggplot2 object

Examples

```
nrows <- 200; ncols <- 4
counts <- matrix(runif(nrows * ncols, 1, 1e4), nrows)
df <- DataFrame(treat = c("A", "A", "B", "B"), sample = seq_len(4))
se <- SummarizedExperiment(
  assays = SimpleList(counts = counts),
  colData = df
)
plotAssayPCA(se, "counts", colour = "treat", label = "sample")
plotAssayPCA(
  se, "counts", colour = "treat", label = "sample",
  inherit.aes = FALSE, size = 5
)
```

plotAssayRle

Plot RLE for a given assay within a SummarizedExperiment

Description

Plot RLE for a given assay within a SummarizedExperiment

Usage

```
plotAssayRle(x, ...)

## S4 method for signature 'SummarizedExperiment'
plotAssayRle(
  x,
  assay = "counts",
  colour = NULL,
  fill = NULL,
  rle_group = NULL,
  by_x = NULL,
  n_max = Inf,
  trans = NULL,
  ...
)
```

Arguments

x	A SummarizedExperiment object
...	Passed to geom_boxplot
assay	The assay to plot
colour	Column from colData(x) to outline the boxplots
fill	Column from colData(x) to fill the boxplots
rle_group	Column from colData(x) to calculate RLE within groups. Commonly an alternative sample label.
by_x	Boxplots will be drawn by this grouping variable from colData(x). If not specified, the default values will be colnames(x)
n_max	Maximum number of points to plot
trans	character(1). Numerical transformation to apply to the data prior to RLE calculation

Details

Uses ggplot2 to create an RLE plot for the selected assay. Any numerical transformation prior to performing the RLE can be specified using the trans argument

Value

A ggplot2 object

Examples

```
nrows <- 200; ncols <- 4
counts <- matrix(runif(nrows * ncols, 1, 1e4), nrows)
df <- DataFrame(treat = c("A", "A", "B", "B"))
se <- SummarizedExperiment(
  assays = SimpleList(counts = counts),
  colData = df
)
plotAssayRle(se, "counts", fill = "treat")
plotAssayRle(se, "counts", fill = "treat", by_x = "treat")
```

plotHFGC

Plot a Genomic Region showing HiC, Features, Genes and Coverage

Description

Plot a region with showing HiC, Features, Genes and Coverage

Usage

```
plotHFGC(
  gr,
  hic,
  features,
  genes,
  coverage,
  annotation,
  zoom = 1,
  shift = 0,
  max = 1e+07,
  axistrack = TRUE,
  cytobands,
  covtype = c("1", "heatmap"),
  linecol = c(),
  gradient = hcl.colors(101, "viridis"),
  hiccol = list(anchors = "lightblue", interactions = "red"),
  featcol,
  genecol,
  annotcol,
  highlight = "blue",
  hicsize = 1,
  featsize = 1,
```



```

genesize = 1,
covsize = 4,
annotsize = 0.5,
hicname = "HiC",
featname = "Features",
featstack = c("full", "hide", "dense", "squish", "pack"),
collapseTranscripts = "auto",
maxTrans = 12,
ylim = NULL,
...,
fontsize = 12,
cex.title = 0.8,
rotation.title = 0,
col.title = "white",
background.title = "lightgray",
title.width = 1.5
)

```

Arguments

gr	The range(s) of interest. Must be on a single chromosome
hic	Any HiC interactions to be included as a GenomicInteractions object. If not supplied, no HiC track will be drawn.
features	A named GRangesList or list of GRangesList objects. Each GRangesList should contain features in each element which will drawn on the same track. If providing a list, each GRangesList within the list will drawn on a separate track. If this argument is not specified, no feature track will be drawn. Features will be drawn with colours provided in featcol.
genes	A GRanges object with exon structure for each transcript/gene. If not included, no track will be drawn for gene/transcript structure
coverage	A named list of BigWigFileList objects containing the primary tracks to show coverage for. Each list element will be drawn on a separate track, with elements within each BigWigFileList shown on the same track. List names will become track names. Alternatively, a single BigWigFileList will plot all individual files on separate tracks. If not included, no coverage tracks will be drawn.
annotation	Annotations for the coverage track(s). A single GRangesList if coverage is a BigWigListList. If coverage is supplied as a list of BigWigFileLists, a named list of GRangesList objects for each coverage track being annotated. Names must match those given for coverage.
zoom	Multiplicative factor for zooming in and out
shift	Shift the plot. Applied after zooming
max	The maximum width of the plotting region. Given that the width of the final plotting window will be determined by any HiC interactions, this argument excludes any interactions beyond this distance. Plotting can be somewhat slow if any long range interactions are included. Ignored if no HiC interactions are supplied.

axistrack	logical. Add an AxisTrack()
cytobands	Cytogenetic bands to be displayed on each chromosome
covtype	The plot type for coverage. Currently only lines ("l") and heatmaps ("heatmap") are supported
linecol	If passing a BigWigFileList to coverage, a vector of colours. If passing a list of BigWigFileList objects to coverage, a list of colours with structure that matches the object being passed to coverage, i.e. a named list of the same length, with elements whose length matches each BigWigFileList. Only used if covtype = "l".
gradient	Colour gradient for heatmaps
hiccol	list with names "anchors" and "interactions". Colours are passed to these elements
featcol	Named vector (or list) of colours for each feature. Must be provided if drawing features
genecol	Named vector (or list) of colours for each gene category
annotcol	Colours matching the coverage annotations
highlight	Outline colour for the highlight track. Setting this to NULL will remove the highlight
hicsize, featsize, genesize, covsize, annotsize	Relative sizes for each track (hic, features, genes, coverage & annotation)
hicname, featname	Names displayed in the LHS panel
featstack	Stacking for the feature track
collapseTranscripts	Passed to GeneRegionTrack for the genes track. Defaults to "auto" for automatic setting. If the number of transcripts to be plotted is > maxtrans, the argument will be automatically set to "meta", otherwise this will be passed as FALSE which will show all transcripts.
maxTrans	Only used if collapseTranscripts is set to "auto".
yylim	If a numeric vector, this will be passed to all coverage tracks. Alternatively, a named list of y-limits for each coverage track with names that match those in each element of the coverage list.
...	Passed to DataTrack for the coverage tracks only. Useful arguments may be things like legend
fontsize	Applied across all tracks
cex.title	Passed to all tracks
rotation.title	Passed to all tracks
col.title	Passed to all tracks
background.title	Passed to all tracks
title.width	Expansion factor passed to plotTracks , and used to widen the panels on the LHS of all tracks. Can have unpredictable effects on the font size of y-axis limits due to the algorithm applied by plotTracks

Details

Convenience function for plotting a common set of tracks. All tracks are optional. For more fine control, users are advised to simply use Gviz directly.

The primary tracks defined in this function are H (HiC), F (features), G (genes), and C (coverage). Axis and Ideogram tracks are an additional part of this visualisation

Use all tracks specific to this dataset to generate a simple visualisation. In descending order the tracks displayed will be:

1. HiC Interactions (if supplied)
2. Regulatory features
3. Genes/genes
4. Coverage tracks as supplied

All tracks are optional and will simply be omitted if no data is supplied. See individual sections below for a more detailed explanation of each track

If wanting a single track of genes, simply pass a GRanges object in the format specified for a [GeneRegionTrack](#). Passing a GRangesList with the same format will yield an individual track for each list element, with each track shown by default as a separate colour. This can be used for showing Up/Down-regulated genes, or Detected/Undetected genes.

If passing a BigWigFileList for the coverage track, each file within the object will be drawn on a separate track. If specified, the same y-limits will be applied to each track. If passing a list of BigWigFileList objects, each list element will be drawn as a single track with the individual files within each BigWigFileList overlaid within each track.

Cytogenetic band information must be in the structure required by [IdeogramTrack](#), with data for both GRCh37 and GRCh38 provided in this package ([grch37.cytobands](#), [grch38.cytobands](#)).

A highlight overlay over the GRanges provided as the `gr` argument will be added if a colour is provided. If set to NULL, no highlight will be added.

Value

A Gviz object

Displaying HiC Interactions

The available arguments for displaying HiC Interactions are defined below. If `hic` is supplied, a single [InteractionTrack](#) will be added displaying all interactions with an anchor within the range specified by `gr`. Only interactions with an anchor explicitly overlapping `gr` will be shown. If no interactions are found within `gr`, the track will not be displayed. **The plotting range will expand to incorporate these interactions**, with the parameter `max` providing an upper limit on the displayed range.

hic This is the `GInteractions` object required for inclusion of a HiC track in the final output. Will be ignored if not supplied

hiccol Determines the colours used for display of anchors and interactions

hicsize Relative size of the track compared to others

hicname The name to display on the LHS panel

max The maximum width of the plotted region. If multiple long-range interactions are identified, this provides an upper limit for the display. This defaults to 10Mb.

Displaying Features

If wanting to add an [AnnotationTrack](#) with regions defined as 'features', the following arguments are highly relevant. All are ignored if features is not provided.

features A named GRangesList. Each element will be considered as a separate feature and drawn as a block in a distinct colour. Any mcols data will be ignored.

featcol A **named** vector (or list) providing a colour for each element of features

featname The name to display on the LHS panel

featstack Stacking to be applied to all supplied features

featsize Relative size of the track compared to others

Displaying Genes And Transcripts

To display genes or transcripts, simply provide a single GRanges object if you wish to display all genes on a single track. The mcols element of this object should contain the columns feature, gene, exon, transcript and symbol as seen on the [GeneRegionTrack](#) help page.

Alternatively, a GRangesList can be provided to display genes on separate tracks based on their category. This can be useful for separating and colouring Up/Down regulated genes in a precise way. All elements should be as described above. Again, all parameters associated with this track-set will be ignored if no object is supplied to this argument.

genes A GRanges or GRangesList object as described above

genecol A single colour if supplying a GRanges object, or a **named** vector/list of colours matching the GRangesList

genesize Relative size of the track compared to others

collapseTranscripts Passed to all tracks. See the GeneRegionTrack section in [settings](#) for detail regarding possible arguments. If genes is a GRangesList, can be a **named** vector/list with names matching the names of the genes object.

Displaying Coverage Tracks

This section contains the most flexibility and can take two types of input. The first option is a BigWigFileList, which will lead to each BigWig file being plotted on it's own track. An alternative is a list of BigWigFileList objects. In this case, each list element will be plotted as a separate track, with all individual BigWig files within each list element overlaid within the relevant track.

In addition to the coverage tracks, annotations can be added to each BigWigFileList in the form of coloured ranges, indicating anything of the users choice. Common usage may be to indicate regions with binding of a ChIP target is found to be detected, unchanged, gained or lost.

coverage A BigWigFileList or list of BigWigFileList objects. A single BigWigFileList will be displayed with each individual file on a separate track with independent y-axes. Each element of the BigWigFileList **must be named** and these names will be displayed on the LHS

panels A list of `BigWigFileList` objects will be displayed with each list element as a separate track, with any BigWig files overlaid using the same y-axis. The list **must be named** with these names displayed on the LHS panel. Each internal BigWig within a `BigWigFileList` must also be named.

covtype Currently only lines (`covtype = "l"`) and heatmaps (`covtype = "heatmap"`) are supported. Colours can be specified using the arguments below

linecol Can be a single colour applied to all tracks, or a *named* vector (or list) of colours. If coverage is a single `BigWigFileList`, these names should match the names of this object exactly. If coverage is a list of `BigWigFileList` objects, `linecol` should be a list with matching names. Each element of this list should also be a **named** vector with names that exactly match those of each corresponding `BigWigFileList`.

gradient A colour gradient applied to all heatmap tracks. No specific structure is required beyond a vector of colours.

covsize Relative size of the tracks compared to others

ylim Can be a vector of length 2 applied to all coverage tracks. Alternatively, if passing a list of `BigWigFileList` objects to the coverage argument, this can be a **named** list of numeric vectors with names matching coverage

annotation Each `BigWigFileList` needs annotations to be passed to this argument as a **named** `GRangesList`, with names being used to associate unique colours with that set of ranges. If coverage is a `BigWigFileList` a simple `GRangesList` would be supplied and a single 'annotation' track will appear at the top of the set of coverage tracks. If coverage is a list, then a **named** list of `GRangesList` objects should be supplied, with each being displayed above the corresponding track from the coverage object.

annotcol A vector of colours corresponding to all names within all `GRangesList` elements supplied as annotation. It is assumed that the same colour scheme will be applied to all annotation tracks and, as such, the colours should **not** be provided as a list which matches the coverage tracks. Instead, every named element anywhere in the annotation `GRanges`, across all of the tracks must be included as a colour

annotsize Relative size of the tracks compared to others

Examples

```
library(rtracklayer)
## Make sure we have the cytobands active
data(grch37.cytobands)

## Prepare the HiC, promoter & transcript information
data(ex_hic, ex_trans, ex_prom)
ex_features <- GRangesList(Promoter = ex_prom)
featcol <- c(Promoter = "red")

## Prepare the coverage
fl <- system.file(
  "extdata", "bigwig", c("ex1.bw", "ex2.bw"), package = "extraChIPs"
)
bwfl <- BigWigFileList(fl)
names(bwfl) <- c("ex1", "ex2")
bw_col <- c(ex1 = "#4B0055", ex2 = "#007094")
```

```

## Define the plotting range
gr <- GRanges("chr10:103862000-103900000")

## Now create the basic plot
plotHFGC(
  gr,
  hic = ex_hic, features = ex_features, genes = ex_trans, coverage = bwfl,
  featcol = featcol, linecol = bw_col, cytobands = grch37.cytobands
)

plotHFGC(
  gr,
  hic = ex_hic, features = ex_features, genes = ex_trans, coverage = bwfl,
  featcol = featcol, linecol = bw_col, cytobands = grch37.cytobands,
  maxTrans = 1
)

```

plotOverlaps

Plot Overlaps Between List Elements

Description

Plot Overlaps between list elements as an upset or Venn diagram

Usage

```

plotOverlaps(x, ...)

## S4 method for signature 'GRangesList'
plotOverlaps(
  x,
  type = c("auto", "venn", "upset"),
  var = NULL,
  f = c("mean", "median", "max", "min", "sd"),
  set_col = NULL,
  ...,
  .sort_sets = "ascending",
  min.gapwidth = 1L,
  ignore.strand = TRUE
)

## S4 method for signature 'list'
plotOverlaps(
  x,
  type = c("auto", "venn", "upset"),

```

```

    set_col = NULL,
    ...,
    .sort_sets = "ascending"
  )

```

Arguments

x	GRangesList of S3 list able to be coerced to character vectors
...	Passed to draw.pairwise.venn (or draw.single/triple.venn) for Venn Diagrams, and to upset for UpSet plots
type	The type of plot to be produced
var	Column to summarised as a boxplot in an upper panel (UpSet plot only)
f	Summarisation function. Must return a single value from any numeric vector
set_col	Colours to be assigned to each set
.sort_sets	passed to <code>sort_sets</code> in upset
min.gapwidth, ignore.strand	Passed to reduce

Details

This function should give the capability to show overlaps for any number of replicates or groups, or a list of items such as gene names. For $n = 2$, a scaled Venn Diagram will be produced, however no scaling is implemented for $n = 3$

UpSet plots are possible for any lists with length > 1 , and are the only implemented possibility for lists > 3 .

If the input is a GRangesList an additional boxplot can be requested using any numeric column within the existing `mcols()` element. Values will be summarised across all elements using the requested function and the boxplot will be included as an upper panel above the intersections

Value

Either a VennDiagram (i.e. grid) object, or a ComplexUpset plot

Examples

```

## Examples using a list of character vectors
ex <- list(
  x = letters[1:5], y = letters[c(6:15, 26)], z = letters[c(2, 10:25)]
)
plotOverlaps(ex, type = "upset")
plotOverlaps(ex, type = "venn", set_col = 1:3, alpha = 0.3)
plotOverlaps(ex, type = "upset", set_col = 1:3, labeller = stringr::str_to_title)
plotOverlaps(ex[1:2])

## GRangesList object will produce a boxplot of summarised values in the
## upper panel
set.seed(100)
grl <- GRangesList(

```

```

a = GRanges(c("chr1:1-10", "chr1:21-30", "chr1:31-40")),
b = GRanges(c("chr1:12-15", "chr1:21-30", "chr1:46-50"))
)
gr1$a$score <- rnorm(3)
gr1$b$score <- rnorm(3)
plotOverlaps(gr1, type = 'upset', var = 'score')

```

plotPie

Draw Pie Graphs based on one or more columns

Description

Draw Pie Graphs based one or more data.frame columns

Usage

```

plotPie(object, ...)

## S4 method for signature 'GRanges'
plotPie(object, scale_by = c("n", "width"), ...)

## S4 method for signature 'DataFrame'
plotPie(object, ...)

## S4 method for signature 'data.frame'
plotPie(
  object,
  fill,
  x,
  y,
  scale_by,
  width = 0.8,
  show_total = TRUE,
  label_fill = "white",
  label_alpha = 1,
  label_size = 3,
  min_p = 0.01,
  show_category = TRUE,
  category_size = 3,
  category_colour = "black",
  category_width = 15,
  ...
)

```


Arguments

object	An object (data.frame)
...	Not used
scale_by	Scale the counts by this column. In this case of a GRanges object this defaults to the count (scale_by = "n") but can also be specified as being width of each range (scale_by = "width"). If choosing width, width will be displayed in Kb
fill	The category/column used to fill the slices of the pie charts
x	The second (optional) category/column to place along the x-axis
y	The final (optional) category/column to place along the y-axis
width	Scale the width of all pies
show_total	logical(1) Show labels on each pie chart with the tally for that complete chart
label_fill	The background colour for tally labels
label_alpha	Transparency for tally labels
label_size	Size of the tally labels. Passed to geom_label
min_p	The minimum proportion of the total required for adding labels. Effectively removes labels from pie charts with few members. Alternatively when only one column is specified, categories below this will not be shown around the edge of the plot
show_category	Show category labels around the edge of the plot if only one category/column is specified
category_size	The size of category labels if only one category/column is specified
category_colour	The colour of category labels if only one column is specified
category_width	Width at which category labels will wrap onto a new line

Details

Using a data.frame as input, this function will draw pie graphs based on one or more columns, by simply counting the values in combination across these columns. One column must be selected for the fill as a bare minimum, with up to three being possible. Additional columns can be set for the x-axis to draw a series of pie-graphs in a row, with a further column able to be added to layout a series of pie graphs in a grid

If only one column/category is chosen, category labels will be added around the edge of the plot

If show_total = TRUE the overall counts for each pie graph will be added in the centre using [geom_label](#). Parameters for these labels are customisable

Value

A ggplot2 object able to be customised with colour scales and themes.

Also note that the \$data element of the returned object will contain the data.frame used for plotting. The additional column label_radians represents the mid-point of each pie slice and can be used for manually adding labels to each pie. Only applies when plotting across the x or y axes

Examples

```

set.seed(200)
df <- data.frame(
  feature = sample(
    c("Promoter", "Enhancer", "Intergenic"), 200, replace = TRUE
  ),
  TF1 = sample(c("Up", "Down", "Unchanged"), 200, replace = TRUE),
  TF2 = sample(c("Up", "Down", "Unchanged"), 200, replace = TRUE),
  w = rexp(200)
)
plotPie(df, fill = "feature")
plotPie(df, fill = "feature", scale_by = "w")
plotPie(df, fill = "feature", x = "TF1")
plotPie(df, fill = "feature", x = "TF1", y = "TF2") +
  scale_fill_viridis_d() +
  theme_bw()

## Manually adding percentages
plotPie(df, fill = "feature", x = "TF1", label_size = 5) +
  geom_label(
    aes(x_lab, y_lab, label = lab),
    data = . %>%
      dplyr::mutate(
        x_lab = x + 0.5*r*sin(label_radians),
        y_lab = 1 + 0.5*r*cos(label_radians),
        lab = scales::percent(p, 0.1)
      ),
    size = 3.5
  )

## And using a GRanges object
data("ex_prom")
gr <- ex_prom
mcols(gr) <- df[seq_along(gr),]
## Show values by counts
plotPie(gr, fill = "feature")
## Show values scaled by width of each range
plotPie(gr, fill = "feature", scale_by = "width")

```

plotProfileHeatmap *Draw a coverage Profile Heatmap*

Description

Plot a coverage Profile Heatmap across multiple ranges

Usage

```

plotProfileHeatmap(object, ...)

## S4 method for signature 'GenomicRangesList'
plotProfileHeatmap(
  object,
  profileCol,
  xValue = "bp",
  fillValue = "score",
  facetX = NULL,
  facetY = NULL,
  colour = facetY,
  linetype = NULL,
  summariseBy = c("mean", "median", "min", "max", "none"),
  xLab = xValue,
  yLab = NULL,
  fillLab = fillValue,
  relHeight = 0.3,
  ...
)

## S4 method for signature 'GenomicRanges'
plotProfileHeatmap(
  object,
  profileCol,
  xValue = "bp",
  fillValue = "score",
  facetX = NULL,
  facetY = NULL,
  colour = facetY,
  linetype = NULL,
  summariseBy = c("mean", "median", "min", "max", "none"),
  xLab = xValue,
  yLab = NULL,
  fillLab = fillValue,
  relHeight = 0.3,
  ...
)

```

Arguments

object	A GRanges or GRangesList object
...	Passed to <code>facet_grid</code> internally. Can be utilised for switching panel strips or passing a labeller function
profileCol	Column name specifying where to find the profile DataFrames
xValue, fillValue	Columns within the profile DataFrames for heatmaps

facetX, facetY	Column used for facetting across the x- or y-axis respectively
colour	Column used for colouring lines in the summary panel. Defaults to any column used for facetY
linetype	Column used for linetypes in the summary panel
summariseBy	Function for creating the summary plot in the top panel. If set to 'none', no summary plot will be drawn. Otherwise the top panel will contain a line-plot representing this summary value for each x-axis bin
xLab, yLab, fillLab	Labels for plotting aesthetics. Can be overwritten using labs() on any returned object
relHeight	The relative height of the top summary panel. Represents the fraction of the plotting area taken up by the summary panel.

Details

Convenience function for plotting coverage heatmaps across a common set of ranges, shared between one or more samples. These are most commonly the coverage values from merged samples within a treatment group. The input data structure is based on that obtained from [getProfileData](#), and can be provided either as a GRanges object (generally for one sample) or as a GRangesList.

A 'profile DataFrame' here refers to a data.frame (or tibble, or DataFrame) with a coverage value in one column that corresponds to a genomic bin of a fixed size denoted in another, as generated by [getProfileData](#). Given that multiple ranges are most likely to be drawn, each profile data frame must be the same size in terms of the number of bins, each of which represent a fixed number of nucleotides. At a minimum this is a two column data frame although [getProfileData](#) will provide three columns for each specified genomic region.

If using a GRangesList, each list element will be drawn as a separate panel by default. These panels will appear in the same order as the list elements of the GRangesList, although this can easily be overwritten by passing a column name to the facetX argument. The default approach will add the original element names as the column "name" which can be seen in the \$data element of any resultant ggplot object produced by this function.

Value

A ggplot2 object, able to be customised using standard ggplot2 syntax

Examples

```
library(rtracklayer)
f1 <- system.file(
  "extdata", "bigwig", c("ex1.bw", "ex2.bw"), package = "extraChIPs"
)
bwf1 <- BigWigFileList(f1)
names(bwf1) <- c("ex1", "ex2")

gr <- GRanges(
  c(
    "chr10:103880281-103880460", "chr10:103892581-103892760",
    "chr10:103877281-103877460"
  )
)
```

```

    )
  )
  pd <- getProfileData(bwfl, gr)
  plotProfileHeatmap(pd, "profile_data") +
    scale_fill_viridis_c(option = "inferno", direction = -1) +
    labs(fill = "Coverage")

```

plotSplitDonut

Draw Two-Level Donut Charts

Description

Create Donut charts based on one or two columns in a data frame

Usage

```

plotSplitDonut(object, ...)

## S4 method for signature 'GRanges'
plotSplitDonut(object, scale_by = c("n", "width"), ...)

## S4 method for signature 'DataFrame'
plotSplitDonut(object, ...)

## S4 method for signature 'data.frame'
plotSplitDonut(
  object,
  inner,
  outer,
  scale_by = NULL,
  r_centre = 0.5,
  r_inner = 1,
  r_outer = 1,
  total_size = 5,
  total_glue = "{comma(N)}",
  inner_glue = "{inner} {.data[[inner]]}\n{percent(p,0.1)}",
  outer_glue = "{outer} {.data[[outer]]}\n{percent(p,0.1)}",
  inner_label = c("label", "text", "none"),
  outer_label = c("label", "text", "none"),
  label_alpha = 1,
  label_size = 3,
  min_p = 0.05,
  explode_inner = NULL,
  explode_outer = NULL,
  explode_query = c("AND", "OR"),
  explode_x = 0,

```

```

  explode_y = 0,
  explode_r = 0,
  nudge_r = 0.5,
  expand = 0.1,
  inner_palette = NULL,
  outer_palette = NULL,
  layout = c(main = area(1, 1, 6, 6), lg1 = area(2, 7), lg2 = area(4, 7)),
  ...
)

```

Arguments

object	A GRanges or data.frame-like object
...	Not used
scale_by	Column to scale values by. If provided, values in this column will be summed, instead of simply counting entries. Any label in the centre of the plot will also reflect this difference
inner	Column name to create the inner ring
outer	Column name to create the outer ring, subset by the inner ring
r_centre	The radius of the hole in the centre. Setting to zero will create a Pie chart
r_inner, r_outer	The radii of the inner/outer rings
total_size	Label size total number of entries in the centre of the plot. Set to NA to hide the label itself
total_glue	glue -syntax for formatting the total which appears in the centre of the plot. Internally, the value N will be calculated and as such, this value should appear within this argument.
inner_glue, outer_glue	glue -syntax for formatting labels which appear on each inner/outer segment. Internally, the values n and p will be calculated as totals and proportions of the total. As such, these values can appear within this argument.
inner_label, outer_label	Can take values 'text', 'label' or 'none'. If setting one of the first two values, the labelling function <code>geom_*</code> will be called, otherwise no label will be drawn
label_alpha	transparency for labels in the inner ring only
label_size	Size of all text labels
min_p	only display labels for segments representing greater than this proportion of the total
explode_inner, explode_outer	Regular expressions from either the inner or outer ring for which segments will be 'exploded'
explode_query	Setting to AND and specifying values for both the inner and outer ring will require matches in both categories
explode_x, explode_y	Numeric values for shifting exploded values

explode_r	Radius expansion for exploded values
nudge_r	Radius expansion for labels in the outer ring
expand	Passed to expansion for both x and y axes
inner_palette	Colour palette for the inner ring
outer_palette	Optional colour palette for the outer ring
layout	Passed to plot_layout

Details

Using a `data.frame` or `GRanges` object, this function enables creation of a Pie/Donut chart with an inner and outer ring. The function itself is extremely flexible allowing for separate colour palettes in the inner and outer rings, as well as highly customisable labels.

Sections can be exploded using a value from the inner ring or outer ring separately, or in combination by setting `explode_query = "AND"`. Exploded sections can be shifted by expanding the radius (`explode_r`), or along the x/y co-ordinates using `explode_x/y`, allowing for detailed placement of sections.

If only the inner palette is specified, segments in the outer ring will be assigned the same colours as the inner segments, but with increased transparency. Only a single legend will be drawn in this scenario. If an outer palette is specified, both colour palettes are completely distinct and two distinct legends will be drawn. The placement of these legends, along with the larger donut plot, can be manually specified by providing a layout as defined in [plot_layout](#). Names are not required on this layout, but may be beneficial for code reproducibility.

The inner label denoting the total can also be heavily customised using the [glue](#) syntax to present the calculated value `N` along with any additional text, such as `'kb'` if scaling `GenomicRanges` by width. The same approach can be taken for the inner and outer labels, where totals are held in the value `n`, proportions are held in the value `p` and the values corresponding to each segment can be accessed using `.data[[inner]]` or `.data[[outer]]`. Values from the inner segments can be added to the outer labels using this strategy enabling a wide variety of `labellinf` approaches to be utilised.

Value

A patchwork object consisting of both `ggplot2` objects and legend grobs

Examples

```
set.seed(200)
df <- data.frame(
  feature = sample(
    c("Promoter", "Enhancer", "Intergenic"), 200, replace = TRUE
  ),
  TF1 = sample(c("Up", "Down", "Unchanged"), 200, replace = TRUE),
  TF2 = sample(c("Up", "Down", "Unchanged"), 200, replace = TRUE)
)
## The standard plot
plotSplitDonut(df, inner = "TF1", outer = "TF2")

## Adding an exploded section along with an outer palette & customisation
plotSplitDonut(
```

```

df, inner = "TF1", outer = "feature", total_size = NA,
label_alpha = 0.5, r_centre = 0,
outer_glue = "{.data[[outer]]}\n(n = {n})", outer_label = "text",
explode_inner = "Up", explode_outer = "Prom|Enh",
explode_query = "AND", explode_r = 0.4,
inner_palette = hcl.colors(3, "Spectral", rev = TRUE),
outer_palette = hcl.colors(3, "Cividis")
)

```

propOverlap

Find the proportions of an overlapping range

Description

Find the proportion of a query range which overlaps the subject

Usage

```

propOverlap(x, y, ...)

## S4 method for signature 'GRanges,GRanges'
propOverlap(x, y, ignore.strand = FALSE, ...)

```

Arguments

`x, y` A GenomicRanges object

`...` Not used

`ignore.strand` If set to TRUE, then the strand of `x` and `y` is set to "*" prior to any computation.

Details

This behaves similarly to [overlapsAny](#) except the proportion of the query range which overlaps one or more subject ranges is returned instead of a logical vector

Value

Numeric vector the same length as `x`

Examples

```

x <- GRanges("chr1:1-10")
y <- GRanges("chr1:1-5")
propOverlap(x, y)
propOverlap(y, x)

```

reduceMC	<i>Reduce ranges retaining mcols</i>
----------	--------------------------------------

Description

Reduce ranges retaining mcols

Usage

```
reduceMC(x, ignore.strand = FALSE, simplify = TRUE, ...)
```

Arguments

x	A GenomicRanges object
ignore.strand	If set to TRUE, then the strand of x and y is set to "*" prior to any computation.
simplify	logical(1). Attempt to simplify returned columns where possible
...	Passed to reduce

Details

This function extends [reduce](#) so that **all** mcols are returned in the output. Where the reduced ranges map to multiple ranges in the original range, mcols will be returned as CompressedList columns.

If simplify = TRUE columns will be returned as vectors where possible.

Value

A GRanges object

Examples

```
x <- GRanges(c("chr1:1-10:+", "chr1:6-12:-"))
x$id <- c("range1", "range2")
reduceMC(x)
reduceMC(x, ignore.strand = TRUE)
```

 setoptsMC

Perform set operations retaining mcols

Description

Perform set operations retaining all mcols from the query range

Usage

```
setdiffMC(x, y, ...)
```

```
intersectMC(x, y, ...)
```

```
unionMC(x, y, ...)
```

```
## S4 method for signature 'GRanges,GRanges'
setdiffMC(x, y, ignore.strand = FALSE, simplify = TRUE, ...)
```

```
## S4 method for signature 'GRanges,GRanges'
intersectMC(x, y, ignore.strand = FALSE, simplify = TRUE, ...)
```

```
## S4 method for signature 'GRanges,GRanges'
unionMC(x, y, ignore.strand = FALSE, simplify = TRUE, ...)
```

Arguments

<code>x, y</code>	GenomicRanges objects
<code>...</code>	Not used
<code>ignore.strand</code>	If set to TRUE, then the strand of <code>x</code> and <code>y</code> is set to "*" prior to any computation.
<code>simplify</code>	logical(1) If TRUE, any List columns will be returned as vectors where possible. This can only occur if single, unique entries are present in all initial elements.

Details

This extends the methods provided by [setdiff](#), [intersect](#) and [union](#) so that mcols from `x` will be returned as part of the output.

Where output ranges map back to multiple ranges in `x`, `CompressedList` columns will be returned. By default, these will be simplified if possible, however this behaviour can be disabled by setting `simplify = FALSE`.

All columns will be returned which can also be time-consuming. A wise approach is to only provide columns you require as part of the query ranges `x`.

If more nuanced approaches are required, the returned columns can be further modified by many functions included in the `plyranges` package, such as `mutate()`.

Value

A GRanges object with all mcols returned from the original object. If a range obtained by setdiff maps back to two or more ranges in the original set of Ranges, mcols will be returned as [CompressedList](#) columns

Examples

```
x <- GRanges("chr1:1-100:+")
x$id <- "range1"
y <- GRanges(c("chr1:51-60:+", "chr1:21-30:-"))
setdiffMC(x, y)
setdiffMC(x, y, ignore.strand = TRUE)

# The intersection works similarly
intersectMC(x, y)

# Union may contain ranges not initially in x
unionMC(x, y)
unionMC(x, y, ignore.strand = TRUE)
```

stitchRanges

Stitch Ranges within a given distance

Description

Stitch together ranges within a given distance, using excluded ranges as barriers that cannot be crossed

Usage

```
stitchRanges(x, exclude, maxgap = 12500L, ignore.strand = TRUE)
```

Arguments

x	Ranges to be stitched together
exclude	Ranges to exclude
maxgap	The maximum distance between ranges to be stitched
ignore.strand	logical

Details

Stitches together ranges within a given distance, using any ranges provided for exclusion as barriers between stitched ranges. This may be particularly useful if wanting to stitch enhancers whilst excluding promoters.

All inputs and outputs are Genomic Ranges objects

Value

A GRanges object

Examples

```
x <- GRanges(c("chr1:1-10", "chr1:101-110", "chr1:201-210", "chr2:1-10"))
y <- GRanges("chr1:200:+")
stitchRanges(x, exclude = y, maxgap = 100)
```

<code>voomWeightsFromCPM</code>	<i>Estimate voom precision weights directly From CPM values</i>
---------------------------------	---

Description

Estimate voom precision weights directly From CPM values

Usage

```
voomWeightsFromCPM(
  cpm,
  design = NULL,
  w0 = NULL,
  lib.size = NULL,
  isLogCPM = TRUE,
  span = 0.5,
  ...
)
```

Arguments

<code>cpm</code>	Matrix of CPM or logCPM values
<code>design</code>	The design matrix for the experiment
<code>w0</code>	Initial vector of sample weights. Should be calculated using arrayWeights
<code>lib.size</code>	Initial library sizes. Must be provided as these are not estimable from CPM values
<code>isLogCPM</code>	logical(1). Indicates whether the data is log2 transformed already. Most commonly (e.g. if using the output of <code>cqn</code>) it will be,
<code>span</code>	Width of the smoothing window used for the lowess mean-variance trend. Expressed as a proportion between 0 and 1.
<code>...</code>	Passed to <code>lmFit</code> internally

Details

This function takes CPM or logCPM values and estimates the precision weights as would be done by providing counts directly to the `voom` function. Using this function enables the use of logCPM values which have been normalised using other methods such as Conditional-Quantile or Smooth-Quantile Normalisation.

The precision weights are returned as part of the `EList` output, and these are automatically passed to the function `lmFit` during model fitting. This will ensure that the mean-variance relationship is appropriate for the linear modelling steps as performed by `limma`.

Initial sample weights can be passed to the function, and should be calculated using `arrayWeights` called on the normalised logCPM values. The returned sample weights will be different to these, given that the function `voomWithQualityWeights` performs two rounds of estimation. The first is on the initial data, with the inappropriate mean-variance relationship, whilst the second round is after incorporation of the precision weights.

Value

An object of class `EList` as would be output by `voom`. Importantly, there will be no `genes` element, although this can be added later. Similarly, the returned `targets` element will only contain sample names and library sizes. This can be incorporated with any other metadata as required.

Plotting data is always returned, noting the the value `sx` has been offset by the library sizes and will be simple logCPM values. As such, the fitted `Amean` is also returned in this list element.

If initial sample weights were provided, modified weights will also be returned, as the initial function `voomWithQualityWeights` performs two rounds of estimation of sample weights. Here we would simply provide the initial weights a priori, with the second round performed within the function. Importantly, this second round of sample weight estimation uses the precision weights ensuring the correct mean-variance relationship is used for the final estimation of sample weights

Examples

```
bamFiles <- system.file("exdata", c("rep1.bam", "rep2.bam"), package="csaw")
wc <- csaw::windowCounts(bamFiles, filter=1)
cpm <- edgeR::cpm(wc, log = TRUE)
e1 <- voomWeightsFromCPM(cpm, lib.size = wc$totals)
```

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