

# Package ‘GenomicInteractions’

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**Type** Package

**Title** R package for handling genomic interaction data

**URL** <https://github.com/ComputationalRegulatoryGenomicsICL/GenomicInteractions/>

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**Imports** Rsamtools, rtracklayer, GenomicRanges, IRanges, BiocGenerics  
(>= 0.15.3), data.table, stringr, GenomeInfoDb, ggplot2, grid,  
gridExtra, methods, igraph, S4Vectors (>= 0.13.13), dplyr,  
Gviz, Biobase, graphics, stats, utils

**Suggests** knitr, BiocStyle, testthat

**VignetteBuilder** knitr

**Description** R package for handling Genomic interaction data, such as  
ChIA-PET/Hi-C, annotating genomic features with interaction  
information and producing various plots / statistics.

**biocViews** Software,Infrastructure,DataImport,DataRepresentation,HiC

**License** GPL-3

**Depends** R (>= 3.3), InteractionSet

**RoxygenNote** 5.0.1

**NeedsCompilation** no

## R topics documented:

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---

GenomicInteractions-package

*GenomicInteractions: A package for analysing chromosome conformation*

---

## Description

GenomicInteractions: A package for analysing chromosome conformation

## Examples

```
library(GenomicInteractions)
```

---

annotateAnchors      *Annotate anchors - DEPRECATED*

---

**Description**

This function is deprecated and will be removed in the next release of Bioconductor. Use 'annotateRegions' instead.

**Usage**

```
annotateAnchors(GIObject, oneOrTwo, name, dat)
```

```
## S4 method for signature 'GenomicInteractions,numeric,character,vector'
annotateAnchors(GIObject,
  oneOrTwo, name, dat)
```

**Arguments**

|          |   |
|----------|---|
| GIObject | A GenomicInteractions object  |
| oneOrTwo | An integer indicating which anchor to annotate  |
| name     | Character. Will be used as a column name for the elementMetadata of the annotated anchor.                       |
| dat      | Vector of the same length as the GenomicInteractions object, containing data with which to annotate the object. |

**Value**

invisible(1)

---

annotateInteractions      *Annotate the interactions in a GInteractions object*

---

**Description**

This function will annotate both anchors with a list of named GRanges objects. Each metadata column is labeled "name.id" and contains the id of the genomic interval(s) it overlaps. Anonymous lists will be given names "FEATURE#.id" where # is the position in the list.

**Usage**

```
annotateInteractions(GIObject, annotations)
```

```
## S4 method for signature 'GInteractions,list'
annotateInteractions(GIObject, annotations)
```

**Arguments**

|             |   |
|-------------|---|
| GIObject    | A GInteractions object to be annotated  |
| annotations | A list containing GRanges (or GRangesList) objects with which to annotate the GInteractions object. |

**Details**

For each anchor a "node.class" metadata column will also be added, containing the name of the list element which was *first* annotated to each range. Ranges with no overlaps will be classified as "distal". The identifiers for each individual feature/annotation are taken from either the name of the list item in the case of a GRangesList or from either the names of a the provided GRanges or an id column in its associated metadata.

**Value**

invisible(1)

**Examples**

```
library("GenomicRanges")
data(hic_example_data)
data(mm9_refseq_promoters)
mm9_refseq_grl = split(mm9_refseq_promoters, mm9_refseq_promoters$id)
annotateInteractions(hic_example_data, list(promoter=mm9_refseq_grl))
```

---

|                 |                         |
|-----------------|-------------------------|
| annotateRegions | <i>Annotate regions</i> |
|-----------------|-------------------------|

---

**Description**

Use this function to add metadata parallel to the 'regions' slot of a GenomicInteractions or GInteractions object.

**Usage**

```
annotateRegions(GIObject, name, dat)

## S4 method for signature 'GInteractions,character,vector'
annotateRegions(GIObject, name, dat)
```

**Arguments**

|          |   |
|----------|---|
| GIObject | A GenomicInteractions or GInteractions object   |
| name     | Character. Will be used as a column name.   |
| dat      | Vector of the same length as the GInteractions object, containing data with which to annotate the object. |

**Value**

invisible(1)

**Examples**

```
data(hic_example_data)
chip <- runif(n = length(regions(hic_example_data)), max = 1000)
annotateRegions(hic_example_data, "chip", chip)
```

---

asBED,GInteractions-method

*Coerce to BED structure*


---

**Description**

Coerce the structure of an object to one following BED-like conventions, i.e., with columns for blocks and thick regions.

**Usage**

```
## S4 method for signature 'GInteractions'
asBED(x, keep.mcols = FALSE, score = "score")
```

**Arguments**

|            |   |
|------------|---|
| x          | Generally, a tabular object to structure as BED   |
| keep.mcols | logical whether to keep non-BED12 columns in final output (may cause problems with some parsers).   |
| score      | character, which field to export as "score" in BED12. Defaults to "auto" which will choose score, then counts, if present, or fill column with zeros. |
| ...        | Arguments to pass to methods  |

The exact behavior depends on the class of ‘object’.

‘GRangesList’ This treats ‘object’ as if it were a list of transcripts, i.e., each element contains the exons of a transcript. The ‘blockStarts’ and ‘blockSizes’ columns are derived from the ranges in each element. Also, add ‘name’ column from ‘names(object)’.

**Value**

A ‘GRanges’, with the metadata columns ‘name’, ‘blockStarts’ and ‘blockSizes’ added.

**Examples**

```
data(hic_example_data)
asBED(hic_example_data)
```

---

availableDisplayPars    *The default display parameters for a track object class can be queried using the availableDisplayPars function.*

---

### Description

The default display parameters for a track object class can be queried using the availableDisplayPars function.

### Usage

```
availableDisplayPars(class)
```

### Arguments

|       |  |
|-------|--|
| class | A valid track object class name, or the object itself, in which case the class is derived directly from it.<br>This function provides the same functionality as <code>Gviz::availableDisplayPars</code> and allows the user to display the default display parameters for the <code>InteractionTrack</code> class. If the class of the track is not an <code>InteractionTrack</code> then the function calls the <code>availableDisplayPars</code> method in <code>Gviz</code> . |
|-------|--|

### Value

returns a list of the default display parameters.

### Examples

```
availableDisplayPars("InteractionTrack")
```

---

calculateDistances    *Calculate interaction distances*

---

### Description

This function takes a `GInteractions` object and calculates the distances between the anchors according to the value of `method`. The distances returned follow the same convention as `distance(x, y)` in `GenomicRanges` where the distance between adjacent regions is 0. Note that if anchors are overlapping this method will print a warning and return the distance as 0.

### Usage

```
calculateDistances(GIObject, method = "midpoint", floor = TRUE)

## S4 method for signature 'GInteractions'
calculateDistances(GIObject, method = "midpoint",
  floor = TRUE)
```

**Arguments**

|          |  |
|----------|--|
| GIObject | A GInteractions object   |
| method   | Character vector indicating how to calculate distances, must be one of 'midpoint', 'outer', 'inner'. |
| floor    | A logical specifying whether to round down distances to nearest base pair or not. Default TRUE.      |

**Value**

An vector containing the distances between anchors/GRanges, NA if on different chromosomes, rounded down to the nearest bp.

**Examples**

```
library(GenomicRanges)

anchor.one = GRanges(c("chr1", "chr1", "chr1", "chr1"), IRanges(c(10, 20, 30, 20), width=5))
anchor.two = GRanges(c("chr1", "chr1", "chr1", "chr2"), IRanges(c(100, 200, 300, 50), width=5))
interaction_counts = sample(1:10, 4)
test <- GenomicInteractions(anchor.one, anchor.two, experiment_name="test",
                             description="this is a test", counts=interaction_counts)
calculateDistances(test, method="midpoint")
```

---

categoriseInteractions

*Get the numbers of interaction types existing in your data*

---

**Description**

Get the numbers of interaction types existing in your data

**Usage**

```
categoriseInteractions(GIObject, node.classes = NULL, viewpoints = NULL)
```

**Arguments**

|              |   |
|--------------|---|
| GIObject     | A GInteractions object  |
| node.classes | Optional. All node.classes to include in the analysis. Default: all node classes.   |
| viewpoints   | Optional. If set will only consider interactions where at least one anchor is of this node class. Default: all classes in node.classes. |

**Value**

A data.frame.

**Examples**

```
library("GenomicRanges")
data(hic_example_data)
data(mm9_refseq_promoters)
mm9_refseq_gr1 = split(mm9_refseq_promoters, mm9_refseq_promoters$id)
annotateInteractions(hic_example_data, list(promoter=mm9_refseq_gr1))
categoriseInteractions(hic_example_data)
```

---

countsBetweenAnchors *Summarise interactions between defined anchors*

---

**Description**

Calculate the number of of paired-end reads mapping between a defined set of anchors. This function will ignore counts present in the input data.

**Usage**

```
countsBetweenAnchors(x, y, ...)

## S4 method for signature 'GInteractions,GRanges'
countsBetweenAnchors(x, y,
  ignore_overlaps = FALSE, ...)
```

**Arguments**

|                 |  |
|-----------------|--|
| x               | A GInteractions object   |
| y               | A GenomicRanges object   |
| ...             | Extra parameters to pass to findOverlaps   |
| ignore_overlaps | Allow overlapping anchors. Use this when you have overlapping anchors but be careful with multi-mapping. The "within" option can help with this. |

**Value**

A GInteractions object with annotated counts between anchors

---

export.bed12 *Export interactions in BED12 format.*

---

**Description**

Export interactions in BED12 format.

**Usage**

```
export.bed12(GIObject, fn = NULL, score = "counts")

## S4 method for signature 'GInteractions'
export.bed12(GIObject, fn = NULL,
  score = "counts")
```



**Arguments**

|          |  |
|----------|--|
| GIObject | A GInteractions object.                  |
| fn       | A filename to write the object to        |
| score    | Which metadata column to export as score |

Exports a GInteractions object to BED12 format, and writes to a specified file. If filename is not specified, then a data.frame containing the information is returned.

Bed12 files provide a method for visualising interactions, it is not a good format for storing all of the data associated with an interaction dataset, particularly for trans-chromosomal interactions, which can only be stored in the bed12 names field.

**Value**

invisible(1) if outputting to file or a data.frame containing all of the corresponding information

**Examples**

```
data(hic_example_data)
export.bed12(hic_example_data, fn = tempfile(), score = "counts")
```

---

|              |  |
|--------------|--|
| export.bedpe | <i>Export interactions in BED Paired-End format.</i> |
|--------------|--|

---

**Description**

#' Exports a GInteractions object to BED-PE format, and writes to a specified file. If filename is not specified, then a data.frame containing the information is returned. The value of the score parameter defines which field is used to populate the score field.

**Usage**

```
export.bedpe(GIObject, fn = NULL, score = "counts")

## S4 method for signature 'GInteractions'
export.bedpe(GIObject, fn = NULL,
             score = "counts")
```

**Arguments**

|          |  |
|----------|--|
| GIObject | A GInteractions object.                      |
| fn       | A filename to write the interactions data to |
| score    | Which metadata column to use as score        |

**Value**

invisible(1) if outputting to file or a data.frame containing all of the corresponding information

**Examples**

```
data(hic_example_data)
export.bedpe(hic_example_data, fn = tempfile(), score = "counts")
```

---

export.chiasig                    *Export interactions in a BEDPE-like format for use with ChiaSig*

---

### Description

Exports a GInteractions object to BEDPE like format, (anchor specifications and a column for reads connecting them) and writes to a specified file. If filename is not specified, then a data.frame containing the information is returned. The value of the score parameter defines which field is used to populate the score field.

### Usage

```
export.chiasig(GIObject, fn = NULL, score = "counts")

## S4 method for signature 'GInteractions'
export.chiasig(GIObject, fn = NULL,
               score = "counts")
```

### Arguments

|          |   |
|----------|---|
| GIObject | A GInteractions object.   |
| fn       | A filename to write the interactions data to                    |
| score    | Which metadata column to use as the score: counts or normalised |

### Value

invisible(1) if outputting to file or a data.frame containing all of the corresponding information

### Examples

```
data(hic_example_data)
export.chiasig(hic_example_data, fn = tempfile(), score = "counts")
```

---

export.igraph                    *Export interactions to an igraph object.*

---

### Description

Exports a GInteractions object to graph.data.frame for use by igraph package. This uses unique anchors as nodes and generates edges between them. For the resulting graph to be easily interpretable, anchors should be non-overlapping. This should already be the case for HiC data (either binned or restriction fragments), however ChIA-PET data can contain overlapping anchors, which may need to be reduced to non-overlapping regions before graph export.

### Usage

```
export.igraph(GIObject)

## S4 method for signature 'GInteractions'
export.igraph(GIObject)
```

**Arguments**

GIObject      A GInteractions object.

**Value**

a graph.data.frame representation of the GInteractions object

**Examples**

```
data(hic_example_data)
ig <- export.igraph(hic_example_data)
```

---

GenomicInteractions      *Function to create a GenomicInteractions object*

---

**Description**

Create GenomicInteractions objects from two GRanges objects.

**Usage**

```
GenomicInteractions(anchor1, anchor2, counts, ...)

## S4 method for signature 'GRanges,GRanges,numeric'
GenomicInteractions(anchor1, anchor2,
  counts, ...)

## S4 method for signature 'GInteractions,ANY,ANY'
GenomicInteractions(anchor1)

## S4 method for signature 'GInteractions,numeric,ANY'
GenomicInteractions(anchor1, anchor2)

## S4 method for signature 'numeric,numeric,GRanges'
GenomicInteractions(anchor1, anchor2,
  counts, ...)

## S4 method for signature 'GRanges,GRanges,GenomicRangesORmissing'
GenomicInteractions(anchor1,
  anchor2, counts, ...)

## S4 method for signature 'missing,missing,GenomicRangesORmissing'
GenomicInteractions(anchor1,
  anchor2, counts, ...)

## S4 method for signature 'ANY,ANY,ANY'
GenomicInteractions(anchor1, anchor2, counts, ...)
```

**Arguments**

anchor1, anchor2  
                   GRanges objects.

counts          An integer vector, defaults to 1.

...              Additional data to be added to mcols

**Value**

a GenomicInteractions object

**Examples**

```
library(GenomicRanges)

anchor.one = GRanges(c("chr1", "chr1", "chr1", "chr1"), IRanges(c(10, 20, 30, 20), width=5))
anchor.two = GRanges(c("chr1", "chr1", "chr1", "chr2"), IRanges(c(100, 200, 300, 50), width=5))
interaction_counts = sample(1:10, 4)
test <- GenomicInteractions(anchor.one, anchor.two, counts=interaction_counts)
```

---

GenomicInteractions-class

*A S4 class to represent interactions between genomic regions.*

---

**Description**

@slot metadata List, defaults to "experiment\_name" and "description", inherited from S4Vectors::Vector  
 @slot anchor\_one,anchor\_two GRanges. Set of anchors of interactions. @slot counts integer vector, contains raw counts @slot elementMetadata DataFrame

This class is used to store information on which genomic regions are interacting with each other. Objects of this class contain information of the genomic coordinates of the interacting regions and the strength of these interactions, and associated metadata such as the name of the dataset and a brief description of the dataset. Interacting regions are stored as a pair of GenomicRanges: each set of anchor regions is stored as a separate GenomicRanges object, accessed by getAnchorOne and getAnchorTwo.

**Examples**

```
showClass("GenomicInteractions")
library(GenomicRanges)

anchor.one = GRanges(c("chr1", "chr1", "chr1", "chr1"), IRanges(c(10, 20, 30, 20), width=5))
anchor.two = GRanges(c("chr1", "chr1", "chr1", "chr2"), IRanges(c(100, 200, 300, 50), width=5))
interaction_counts = sample(1:10, 4)
test <- GenomicInteractions(anchor.one, anchor.two, counts=interaction_counts)
```

---

getters

*Functions to access data held in a GenomicInteractions object.*

---

## Description

Use these functions to access data stored in each of the slots of a GenomicInteractions object.

## Usage

```
name(GIObject)

anchorOne(GIObject)

anchorTwo(GIObject)

interactionCounts(GIObject)

annotationFeatures(GIObject)

## S4 method for signature 'GInteractions'
name(GIObject)

## S4 method for signature 'GInteractions'
description(object)

## S4 method for signature 'GInteractions'
anchorOne(GIObject)

## S4 method for signature 'GInteractions'
anchorTwo(GIObject)

## S4 method for signature 'GInteractions'
interactionCounts(GIObject)

## S4 method for signature 'GInteractions'
annotationFeatures(GIObject)
```

## Arguments

|          |  |
|----------|--|
| GIObject | A Gnteractions object  |
| object   | Object, possibly derived from class <a href="#">eSet-class</a> . |

## Value

For 'anchorOne' and 'anchorTwo', a GRanges. For 'interactionCounts', a numeric vector with counts for each interaction in the object. For 'description' and 'name', a character vector with length 1. For 'annotationFeatures', a character vector of features with which the object was previously annotated, or 'NA' if the object is unannotated.

**Examples**

```

library(GenomicRanges)

anchor.one = GRanges(c("chr1", "chr1", "chr1", "chr1"), IRanges(c(10, 20, 30, 20), width=5))
anchor.two = GRanges(c("chr1", "chr1", "chr1", "chr2"), IRanges(c(100, 200, 300, 50), width=5))
interaction_counts = sample(1:10, 4)
test <- GenomicInteractions(anchor.one, anchor.two, counts=interaction_counts)

name(test)
description(test)
anchorOne(test)
anchorTwo(test)
interactionCounts(test)

```

---

```

get_binom_ligation_threshold
      get self ligation threshold with binomial test

```

---

**Description**

This function calculates a self ligation threshold according to a method based on that of Heidari et al., Genome Research, 2014. Briefly, paired reads are divided into evenly spaced bins. For each bin, the number of reads that are aligned to opposite strand vs to the same strand is calculated. A binomial test is used to test if this is significantly different from the 50:50 ratio expected by chance if all reads are real interactions.

**Usage**

```

get_binom_ligation_threshold(GIObject, max.distance = 20000, bin.size = 500,
  p.cutoff = 0.05, adjust = "fdr", plot = TRUE)

```

**Arguments**

|              |   |
|--------------|---|
| GIObject     | a GInteractions object of paired end reads  |
| max.distance | The maximum distance to consider between reads. Reads further apart than this distance should be very unlikely to be self ligations.  |
| bin.size     | Bin size in base pairs.   |
| p.cutoff     | P value cut off for a significant difference from 50:50. Default: 0.05  |
| adjust       | Method to use to adjust p values. Default: fdr. See 'help(p.adjust)' for accepted values. Can also be NA for no adjustment.           |
| plot         | TRUE by default. Whether to plot the percentage of reads on opposite strands vs difference and the binomial test p value vs distance. |

**Value**

The cutoff in base pairs below which an interaction is likely to be a self ligation.

---

`get_self_ligation_threshold`*Get self ligation threshold with SD method from Heidari et al*

---

**Description**

This function calculates a self ligation threshold according to the method published in Heidari et al., Genome Research, 2014. Briefly, paired reads are divided into evenly sized bins. For each bin, the log<sub>2</sub> ratio of reads that are aligned to opposite strand vs to the same strand is calculated. Twice the standard deviation of this ratio at high distances is used as a cutoff to determine which bins are likely to contain mostly self-ligated reads.

**Usage**

```
get_self_ligation_threshold(GIObject, bins = 100, distance_th = 4e+05,  
plot = TRUE)
```

**Arguments**

|                          |   |
|--------------------------|---|
| <code>GIObject</code>    | a <code>GInteractions</code> object of paired end reads   |
| <code>bins</code>        | Number of evenly sized bins to use.   |
| <code>distance_th</code> | The threshold, in base pairs, to use as a cutoff to pick which bins to use to determine the standard deviation. |
| <code>plot</code>        | TRUE by default. Whether to plot the log <sub>2</sub> ratio of opposite to same strand reads vs distance.       |

**Value**

The cutoff in base pairs below which an interaction is likely to be a self ligation.

---

`hg19.refseq.transcripts`*Human Refseq transcripts from chr 17-18*

---

**Description**

This dataset contains a subset of the transcripts from the Refseq annotation for mouse genome build hg19. See the ChIA-PET analysis vignette (`vignettes(GenomicInteractions)`) for more information on how this dataset was created.

**Usage**

```
data(hg19.refseq.transcripts)
```

**Format**

A `GRanges` object with length 2441.

**Value**

A `GRanges` object.

hic\_example\_data      *Example HiC dataset*

---

### Description

This dataset contains HiC data from Seitan et al. 2013. The data was analysed using HOMER (Heinz et al. 2010) at a resolution of 100kb to find significant interactions. This example dataset has been filtered to retain only interactions on chromosomes 14 and 15 with a FDR < 0.1. The data has also been annotated for overlaps with Refseq promoters. See the HiC analysis vignette (`vignettes(GenomicInteractions)`) for more information on how this dataset was created.

### Usage

```
data(hic_example_data)
```

### Format

A `GenomicInteractions` object with length 8171.

### Value

`GenomicInteractions` object

### References

Seitan, V. C. et al. Cohesin-based chromatin interactions enable regulated gene expression within pre-existing architectural compartments. *Genome Res.* 23, 2066-77 (2013).

Heinz S, Benner C, Spann N, Bertolino E et al. Simple Combinations of Lineage-Determining Transcription Factors Prime cis-Regulatory Elements Required for Macrophage and B Cell Identities. *Mol Cell* 2010 May 28;38(4):576-589.

---

InteractionTrack      *Constructor to create an InteractionTrack object*

---

### Description

Create `InteractionTrack` object from an `GenomicInteractions` object to visualise a specified chromosome.

### Usage

```
InteractionTrack(x, chromosome = "", name = NULL, start = NULL,
end = NULL)
```



**Arguments**

|            |   |
|------------|---|
| x          | A GenomicInteractions object  |
| chromosome | specify which chromosome to hold information on - can be null                                     |
| name       | specify the name of the track - if null takes it to be the name of the GenomicInteractions passed |
| start      | specify which start location to hold information on - can be null                                 |
| end        | specify which end location to hold information on - can be null                                   |

**Value**

an InteractionTrack object

**Examples**

```
library(Gviz)

anchor.one = GRanges(c("chr1", "chr1", "chr1", "chr1"), IRanges(c(10, 20, 30, 20), width=5))
anchor.two = GRanges(c("chr1", "chr1", "chr1", "chr2"), IRanges(c(100, 200, 300, 50), width=5))
interaction_counts = sample(1:10, 4)
test <- GenomicInteractions(anchor.one, anchor.two, experiment_name="test",
                             description="this is a test", counts=interaction_counts)
interactions.track = InteractionTrack(name="Test", test, chromosome="chr1")
plotTracks(list(interactions.track), chromosome="chr1", from=0, to=500)
```

---

**InteractionTrack-class**

*A class to hold chromatin interaction data for a specific genomic region.*

---

**Description**

@slot plottingFunction function @slot variables list @slot chromosome chromosome @slot stacking character

**Details**

InteractionTrack is a specific Gviz-derived class for enabling the visualisation of chromatin interaction data. The InteractionTrack class allows interactions on a specified chromosome to be visualised by examining interactions between anchors as bezier curves. The object is instantiated and used in a similar fashion to standard Gviz tracks and plotted using the plotTracks.

Several additional display parameters (i.e. displayPars(foo)=list(...)) are defined for this class, including plot.anchors which can be used to specify whether anchors are to be drawn. col.anchors.line which can be used to alter the colour of border of these anchor elements and col.anchors.fill can be used to alter the fill colour of these elements. The value of plot.outside determines whether or not interactions which span outside of the window are to be plotted, and col.outside defines the colour of these interactions. Similarly plot.trans determines whether trans-interactions are plotted and col.trans specifies the colour of trans-interactions. By default,

the height of an arc representing an interaction is proportional to the number of reads/counts supporting that interaction. Instead of using the counts to define this, the height can be set to be proportional to either `fdr` or `p.value` using the `interaction.measure` display parameter. By changing the `interaction.dimension` to `width`, the line widths of each arc now represent the statistic supporting them. The heights of the arcs can be made to be proportional to `log10` of the supporting statistic by changing `interaction.dimension.transform` to `log`. `col.interactions` sets the colour of arcs representing interactions within the region of interest. It is possible to colour the arcs by the type of interaction they are involved in (i.e. promoter-promoter interactions etc) by setting the `col.interactions.types` display parameter to be a named vector of colours, where the name corresponds to the type of interaction. This is applicable to anchors regions through the use of the `col.anchors.line.node.class` and `col.anchors.fill.node.class` parameters.

---

is.pp

*Interaction Type Helpers*


---

## Description

Functions to classify interactions within `GInteractions` objects.

- "isInteractionType" takes two character arguments which are annotated node classes and returns interactions between them.
- "is.pp", "is.pd" etc. are bindings for common annotations:
  - p** promoter
  - d** distal
  - t** terminator
- "is.trans" & "is.cis" select trans-chromosomal and intra-chromosomal interactions, respectively

## Usage

```
is.pp(GIObject)

is.pd(GIObject)

is.pt(GIObject)

is.dd(GIObject)

is.dt(GIObject)

is.tt(GIObject)

isInteractionType(GIObject, x, y)

is.trans(GIObject)

is.cis(GIObject)

## S4 method for signature 'GInteractions'
is.pp(GIObject)
```

```
## S4 method for signature 'GInteractions'  
is.pd(GIObject)  
  
## S4 method for signature 'GInteractions'  
is.pt(GIObject)  
  
## S4 method for signature 'GInteractions'  
is.dd(GIObject)  
  
## S4 method for signature 'GInteractions'  
is.dt(GIObject)  
  
## S4 method for signature 'GInteractions'  
is.tt(GIObject)  
  
## S4 method for signature 'GInteractions'  
isInteractionType(GIObject, x, y)  
  
## S4 method for signature 'GInteractions'  
is.trans(GIObject)  
  
## S4 method for signature 'GInteractions'  
is.cis(GIObject)
```

### Arguments

|          |                                 |
|----------|---------------------------------|
| GIObject | A GInteractions object          |
| x, y     | Names of annotated node classes |

### Value

A logical vector

### Examples

```
data(hic_example_data)  
table(is.cis(hic_example_data))  
sum(interactionCounts(hic_example_data))
```

---

makeGenomicInteractionsFromFile

*Function to create GenomicInteraction objects from a file*

---

### Description

Function to create GenomicInteraction objects from a variety of files. The resulting objects contain information on which genomic regions are interacting with each other, and the number of counts supporting each interaction. It is also possible to store information on associated p-values and false-discovery rates (FDR). It is possible to create GenomicInteractions objects for various datasets

including Hi-C and ChIA-PET. It is possible to read interactions from a variety of files including BAM files, bed files (BED12 and BEDPE) and from the output from standard processing pipelines, such as HOMER and ChIA-PET tool. GenomicInteractions objects can also be created using calls of the form `new("GenomicInteractions", ...)`. For hiclib, it expects the directory in which the files extracted using `h5dictToTxt.py` from the hdf5 file are located, where as for all of the other file types it expects the full filename. Note that recent versions of hiclib (2015-) cannot export the required data and so this function will only work with older files.

### Usage

```
makeGenomicInteractionsFromFile(fn, type, experiment_name = "",
                               description = "", chr_names = NULL)
```

### Arguments

|                              |   |
|------------------------------|---|
| <code>fn</code>              | Filename or, if type="hiclib", folder   |
| <code>type</code>            | One of "chiapet.tool", "bed12", "bedpe", "hiclib", "homer", "bam", "two.bams".              |
| <code>experiment_name</code> | Experiment name.  |
| <code>description</code>     | Description of experiment.  |
| <code>chr_names</code>       | a vector of chromosome names in order, required for re-naming chromosomes for hiclib import |

### Value

a GenomicInteractions object

### Examples

```
k562.rep1 <- makeGenomicInteractionsFromFile(
  system.file(package="GenomicInteractions", "extdata", "k562.rep1.cluster.pet3+.txt"),
  type="chiapet.tool", experiment_name="k562", description="k562 pol2 8wg16")
```

```
k562.rep1
```

---

mm9\_refseq\_promoters *Mouse Refseq promoters from chr 14-15*

---

### Description

This dataset contains a subset of the promoters from the Refseq annotation for mouse genome build mm9. See the HiC analysis vignette (`vignettes(GenomicInteractions)`) for more information on how this dataset was created.

### Usage

```
data(mm9_refseq_promoters)
```

**Format**

A GRanges object with length 2441.

**Value**

A GRanges object.

---

|                  |  |
|------------------|--|
| plotAvgViewpoint | <i>Plot coverage around a set of virtual 4C viewpoints</i> |
|------------------|--|

---

**Description**

Plots summarised coverage of interactions around a set of viewpoints, e.g. promoters. This function requires the output of 'viewPoint()' as input.

**Usage**

```
plotAvgViewpoint(x, left_dist = 1e+05, right_dist = 1e+05,
  ylab = "Average signal", xlab = "Relative position", fix = "center",
  ...)
```

**Arguments**

|            |  |
|------------|--|
| x          | A GInteractions object which is output from viewPoint  |
| left_dist  | Distance 'left' of interactions to consider, in bp.  |
| right_dist | Distance 'right' of interactions to consider, in bp.   |
| ylab       | Y axis label.  |
| xlab       | X axis label.  |
| fix        | One of "center", "start", "end". Passed to 'resize'. Interaction distances are calculated relative to this part of the bait. |
| ...        | additional arguments to plot   |

**Value**

Coverage that is plotted (invisibly)

**Examples**

```
data(hic_example_data)
library(GenomicRanges)
pos <- GRanges(seqnames="chr15", ranges=IRanges(start=59477709, end=59482708))
region <- GRanges(seqnames="chr15", ranges=IRanges(start=58980209, end=59980208))
vp <- viewPoint(hic_example_data, pos, region)
plotAvgViewpoint(vp, left_dist = 1000000, right_dist = 1000000)
```

---

|              |  |
|--------------|--|
| plotCisTrans | <i>Plots the percentages of cis and trans interactions for a GInteractions object as a donut plot.</i> |
|--------------|--|

---

**Description**

Plots the percentages of cis and trans interactions for a GInteractions object as a donut plot.

**Usage**

```
plotCisTrans(GIObject)
```

**Arguments**

GIObject      A GInteractions object

**Value**

A ggplot2 plot

**Examples**

```
data(hic_example_data)
plotCisTrans(hic_example_data)
```

---

|            |   |
|------------|---|
| plotCounts | <i>Plot a bar chart of the number of interactions supported by different numbers of reads in your data.</i> |
|------------|---|

---

**Description**

Plot a bar chart of the number of interactions supported by different numbers of reads in your data.

**Usage**

```
plotCounts(GIObject, normalise = FALSE, cut = 10)
```

**Arguments**

GIObject      A GInteractions object.  
 normalise     Logical. If TRUE, plots proportion of total reads instead of count.  
 cut            Numeric, can be NULL. Default: 10. All interactions with counts > cut are consolidated into a single category.

**Value**

A ggplot2 plot

**Examples**

```
data(hic_example_data)
plotCounts(hic_example_data)
plotCounts(hic_example_data, normalise=TRUE)
```

---

|           |  |
|-----------|--|
| plotDists | <i>Plots a histogram of interaction distances for a GInteractions Object</i> |
|-----------|--|

---

**Description**

Plots a histogram of interaction distances for a GInteractions Object

**Usage**

```
plotDists(GIObject, breaks = c(0, 1000, 5000, 10000, 50000, 1e+05, 5e+05,
  1e+06, 2e+06), method = "midpoint")
```

**Arguments**

|          |   |
|----------|---|
| GIObject | A GInteractions object  |
| breaks   | A numeric vector of breaks for the histogram  |
| method   | Method used for distance between anchors. Passed to calculateDistances. One of "midpoint", "inner", or "outer". |

**Value**

A ggplot2 plot

**Examples**

```
data(hic_example_data)
plotDists(hic_example_data)
```

---

|                            |   |
|----------------------------|---|
| plotInteractionAnnotations | <i>Plot a donut plot of interaction types for an annotated GInteractions object</i> |
|----------------------------|---|

---

**Description**

Plot a donut plot of interaction types for an annotated GInteractions object

**Usage**

```
plotInteractionAnnotations(GIObject, node.classes = NULL, viewpoints = NULL,
  other = 0, keep.order = FALSE, legend = FALSE)
```

**Arguments**

|              |   |
|--------------|---|
| GIObject     | A GInteractions object  |
| node.classes | Optional. All node.classes to include in the analysis. Default: all node classes.   |
| viewpoints   | Optional. If set will only consider interactions where at least one anchor is of this node class. Default: all classes in node.classes.         |
| other        | Optional. Interaction types making up fewer than "other" percent of the total interactions will be consolidated into a single "other" category. |
| keep.order   | Optional. Logical. Keep original order of node.classes for plotting or not. Default: FALSE, alphabetical order.                                 |
| legend       | Optional. Logical. If TRUE, legend is plotted to right of donut plot. If FALSE, donut plot is annotated with category names.                    |

**Value**

A ggplot2 plot

**Examples**

```
library("GenomicRanges")
data(hic_example_data)
data(mm9_refseq_promoters)
mm9_refseq_gr1 = split(mm9_refseq_promoters, mm9_refseq_promoters$id)
annotateInteractions(hic_example_data, list(promoter=mm9_refseq_gr1))
plotInteractionAnnotations(hic_example_data)
```

---

|                  |   |
|------------------|---|
| plotSummaryStats | <i>Plot summary statistics for a GInteractions object</i> |
|------------------|---|

---

**Description**

Makes summary plots of the counts, interaction distances, interaction annotations, and percentage of cis and trans interactions for a GInteractions object using 'plotCounts', 'plotDists', 'plotCisTrans', and 'plotInteractionAnnotations'.

**Usage**

```
plotSummaryStats(GIObject, other = 5, cut = 10)
```

**Arguments**

|          |  |
|----------|--|
| GIObject | A GInteractions object   |
| other    | Default 5. Passed to plotInteractionAnnotations. Interaction types making up fewer than "other" percent of the total interactions will be consolidated into a single "other" category. |
| cut      | Default 10. Passed to plotCounts. All interactions with counts > cut are consolidated into a single category.  |

**Value**

invisible(1)



**Examples**

```
data(hic_example_data)
plotSummaryStats(hic_example_data)
```

---

|               |  |
|---------------|--|
| plotViewpoint | <i>Plot coverage around a virtual 4C viewpoint</i> |
|---------------|--|

---

**Description**

Plots coverage of interactions around a given viewpoint. This function requires the output of 'viewPoint()' as input. You should additionally specify the total region you wish to plot.

**Usage**

```
plotViewpoint(x, region, ylab = "Signal", xlab = NULL, ...)
```

**Arguments**

|        |  |
|--------|--|
| x      | a GInteractions object which is output from viewPoint                                |
| region | The genomic region to plot   |
| ylab   | Y axis label.  |
| xlab   | X axis label. By default this is the chromosome of the region that is being plotted. |
| ...    | additional arguments to plot   |

**Value**

Coverage that is plotted (invisibly)

**Examples**

```
data(hic_example_data)
library(GenomicRanges)
pos <- GRanges(seqnames="chr15", ranges=IRanges(start=59477709, end=59482708))
region <- GRanges(seqnames="chr15", ranges=IRanges(start=58980209, end=59980208))
vp <- viewPoint(hic_example_data, pos, region)
plotViewpoint(vp, region)
```

---

|            |   |
|------------|---|
| removeDups | <i>Remove all but one occurrences of a duplicated interaction</i> |
|------------|---|

---

**Description**

Removes all but the first occurrence of a duplicated interaction (defined as having identical coordinates for both anchors). N.B. this does not summarise the total counts of all the duplicates. It is designed for removing potential PCR duplicates after reading in .bam files.

**Usage**

```
removeDups(GIObject)
```

**Arguments**

GIObject            A GInteractions object.

**Value**

A GInteractions object that is a subset of the input object.

---

|                  |   |
|------------------|---|
| resetAnnotations | <i>Reset annotations made to a GInteractions object</i> |
|------------------|---|

---

**Description**

This function removes all annotations from a GInteractions object by deleting all of the metadata columns associated with both anchors.

**Usage**

```
resetAnnotations(GIObject)
```

```
## S4 method for signature 'GInteractions'
resetAnnotations(GIObject)
```

**Arguments**

GIObject            An annotated GInteractions object

**Value**

```
invisible(1)
```

**Examples**

```
data(hic_example_data)
resetAnnotations(hic_example_data)
```

---

|            |  |
|------------|--|
| sameStrand | <i>Tests whether anchors have the same strand.</i> |
|------------|--|

---

**Description**

This is designed for processing .bam files.

**Usage**

```
sameStrand(GIObject)
```

**Arguments**

GIObject      A GInteractions object

**Value**

A logical vector denoting with TRUE if both anchors of an interaction are on the same strand and FALSE otherwise.

---

|         |  |
|---------|--|
| setters | <i>Functions to set data held in a GInteractions object.</i> |
|---------|--|

---

**Description**

Use these functions to set data stored in each of the slots of a GInteractions object.

**Usage**

```
name(GIObject) <- value

interactionCounts(GIObject) <- value

## S4 replacement method for signature 'GInteractions'
name(GIObject) <- value

## S4 replacement method for signature 'GInteractions,ANY'
description(object) <- value

## S4 replacement method for signature 'GInteractions'
interactionCounts(GIObject) <- value
```

**Arguments**

GIObject      A GenomicInteractions object  
value          A vector to replace a slot in the object  
object         Object, possibly derived from class [eSet-class](#).

**Value**

GenomicInteractions object

**Examples**

```
library(GenomicRanges)

anchor.one = GRanges(c("chr1", "chr1", "chr1", "chr1"), IRanges(c(10, 20, 30, 20), width=5))
anchor.two = GRanges(c("chr1", "chr1", "chr1", "chr2"), IRanges(c(100, 200, 300, 50), width=5))
interaction_counts = sample(1:10, 4)
test <- GenomicInteractions(anchor.one, anchor.two, experiment_name="test",
                           description="this is a test", counts=interaction_counts)

name(test) <- "Mouse test"
name(test)

description(test) <- "This is a test using the mouse genome"
description(test)

interactionCounts(test) <- c(2,3,8,5)
interactionCounts(test)
```

---

|                  |  |
|------------------|--|
| subsetByFeatures | <i>Subset a GInteractions object by features</i> |
|------------------|--|

---

**Description**

Subsets interactions for which at least one of the anchors overlaps with a given GRanges object. Alternatively, subsets interactions based on annotated feature IDs for a particular feature.

**Usage**

```
subsetByFeatures(GIObject, features, feature.class = NULL)

## S4 method for signature 'GInteractions,GRanges,missing'
subsetByFeatures(GIObject, features,
  feature.class = NULL)

## S4 method for signature 'GInteractions,GRangesList,missing'
subsetByFeatures(GIObject,
  features, feature.class = NULL)

## S4 method for signature 'GInteractions,character,character'
subsetByFeatures(GIObject,
  features, feature.class = NULL)
```

**Arguments**

GIObject            A GInteractions object

`features` A GRanges or GRangesList object, or a character vector containing IDs of annotated features, e.g. promoter IDs.

`feature.class` If 'features' is a character vector, the corresponding feature name, e.g. "promoter".

**Value**

a subsetted GInteractions object

**Examples**

```
data("hic_example_data")
data("mm9_refseq_promoters")
annotateInteractions(hic_example_data, list(promoter = mm9_refseq_promoters))
ids <- names(mm9_refseq_promoters[1:10])
subsetByFeatures(hic_example_data, ids, "promoter")
```

---

sum,GInteractions-method

*Return the total number of interactions in a GInteractions GObject*

---

**Description**

Return the total number of interactions in a GInteractions GObject

**Usage**

```
## S4 method for signature 'GInteractions'
sum(x)
```

**Arguments**

`x` GInteractions GObject

**Value**

The sum of the counts in GObject

---

summariseByFeaturePairs

*Summarise the number of interactions between two sets of features.*

---

**Description**

This function will calculate the number of observed interactions between two sets of features provided by the end-user. This allows the summarisation of the number of features of a specific type a particular region is involved in and how many interactions exist between them.

**Usage**

```
summariseByFeaturePairs(GIObject, features.one, feature.name.one, features.two,
  feature.name.two)

## S4 method for signature 'GInteractions'
summariseByFeaturePairs(GIObject, features.one,
  feature.name.one, features.two, feature.name.two)
```

**Arguments**

```
GIObject      An annotated GInteractions object
features.one  A GRanges object containing the feature set of interest
feature.name.one
              The name of the first feature set of interest
features.two  A GRanges object containing the second feature set of interest
feature.name.two
              The name of the second feature set of interest
```

**Value**

A data frame with one line for each range in ‘features’

**Examples**

```
data("hic_example_data")
data("mm9_refseq_promoters")
data("thymus_enhancers")
annotateInteractions(hic_example_data, list(promoter = mm9_refseq_promoters, enhancer = thymus_enh))
# can be slow so subset of features used for examples
p <- unique(unlist(head(regions(hic_example_data)$promoter.id)))
e <- unique(unlist(head(regions(hic_example_data)$enhancer.id)))
p <- p[!is.na(p)]
p <- mm9_refseq_promoters[p]
e <- e[!is.na(e)]
e <- thymus_enh[e]
ep_summary <- summariseByFeaturePairs(hic_example_data, p, "promoter", e, "enhancer")
```

---

summariseByFeatures     *Summary statistics of interactions for a given feature set*

---

**Description**

This function will calculate summary statistics for each element in the given feature set, including the number of interactions (the sum of all interaction counts), number of unique interactions and number of trans- (interchromosomal) interactions. It also returns some statistics for the distances of interactions for all interactions of the feature, and for the different interaction types e.g. promoter-distal.

**Usage**

```
summariseByFeatures(GIObject, features, feature.name,
  distance.method = "midpoint", annotate.self = FALSE)

## S4 method for signature 'GInteractions'
summariseByFeatures(GIObject, features, feature.name,
  distance.method = "midpoint", annotate.self = FALSE)
```

**Arguments**

|                 |   |
|-----------------|---|
| GIObject        | An annotated GInteractions object   |
| features        | A GRanges object containing the feature set   |
| feature.name    | The name of the feature set   |
| distance.method | Method for calculating distances between anchors, see <code>?calculateDistances</code>  |
| annotate.self   | Logical. Indicates whether to annotate self interactions, i.e. where a feature in 'features' overlaps both anchors of an interaction. Default: FALSE. |

**Value**

A data frame with one line for each range in 'features'

**Examples**

```
data("hic_example_data")
data("mm9_refseq_promoters")
annotateInteractions(hic_example_data, list(promoter = mm9_refseq_promoters))
summariseByFeatures(hic_example_data, mm9_refseq_promoters[1:10], "promoter")
```

---

thymus\_enh

*Putative enhancers from mouse thymus data*

---

**Description**

This dataset contains a set of mouse thymus enhancers derived from ChIP-seq data from mouse thymus, as described in Shen et al. 2012. See the HiC analysis vignette for more details. (`vignettes(GenomicInteraction)`)

**Usage**

```
data("thymus_enhancers")
```

**Format**

A GRanges object

**Value**

A GRanges object

**References**

Shen, Y et al. A map of cis-regulatory sequences in the mouse genome. *Nature* (2012).

---

updateObject, GenomicInteractions-method  
*updateObject method for GenomicInteractions 1.3.7 and earlier*

---

### Description

updateObject method for GenomicInteractions 1.3.7 and earlier

### Usage

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

### Arguments

|         |  |
|---------|--|
| object  | Object to be updated for updateObject and updateObjectFromSlots.<br>Object for slot information to be extracted from for getObjectSlots.   |
| ...     | Additional arguments, for use in specific updateObject methods.  |
| verbose | TRUE or FALSE, indicating whether information about the update should be reported. Use <a href="#">message</a> to report this information. |

### Value

A GenomicInteractions object

---

|           |                             |
|-----------|-----------------------------|
| viewPoint | <i>Virtual 4C viewpoint</i> |
|-----------|-----------------------------|

---

### Description

This function creates a GInteractions object representing interactions originating at a given viewpoint ("bait"), or set of viewpoints. This is similar to the idea of a virtual 4C experiment where you are interested in interactions with a specific region.

### Usage

```
viewPoint(x, bait, region = NULL, ...)
```

### Arguments

|        |  |
|--------|--|
| x      | A GInteractions object.  |
| bait   | A GRanges object describing bait regions.  |
| region | If present, a GRanges object specifying the region to look for bait interactions in. |
| ...    | additional arguments to findoverlaps   |



**Details**

The object returned has the "bait" as anchor one, and the interacting regions as anchor two. By default this is genome wide. If you only want to consider interactions within a certain distance around the bait, you can specify a region to consider.

Multiple baits can be given, e.g. to find all interactions around promoters.

You may want to visualise the resulting interactions in a genome browser - you can do this by creating coverage over anchor two of the object and exporting as a wig or bedgraph file.

**Value**

A GInteractions object.

**Examples**

```
data(hic_example_data)
library(GenomicRanges)
pos <- GRanges(seqnames="chr15", ranges=IRanges(start=59477709, end=59482708))
region <- GRanges(seqnames="chr15", ranges=IRanges(start=58980209, end=59980208))
vp <- viewPoint(hic_example_data, pos, region)
```

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