

# Package ‘CNEr’

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**Title** CNE Detection and Visualization

**Description** Large-scale identification and advanced visualization of sets of conserved noncoding elements.

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|                      |                            |
|----------------------|----------------------------|
| <i>addAncestorGO</i> | <i>Add ancestor GO IDs</i> |
|----------------------|----------------------------|

---

## Description

Given a list of GO IDs, add the corresponding ancestor GO IDs.

## Usage

```
addAncestorGO(go)
```

## Arguments

|           |                                                          |
|-----------|----------------------------------------------------------|
| <i>go</i> | A list of GO IDs. The elements of the list can be empty. |
|-----------|----------------------------------------------------------|

## Details

The ancestor GO IDs for each GO ID are added to the elements.

## Value

A list of GO IDs with their ancestor GO IDs.

## Note

This function is mainly designed for processing the gff annotation generated from interproscan, where for each gene, a set of GO IDs are assigned. However, for GO enrichment analysis, we need a list of mapping from genes to the GO IDs and their ancestor GO IDs as well.

**Author(s)**

Ge Tan

**Examples**

```
## Not run:
library(GO.db)
go <- list(c("GO:0005215", "GO:0006810", "GO:0016020"), "GO:0016579")
addAncestorGO(go)

## End(Not run)
```

---

axisTrack

*Example data for plotting annotation.*


---

**Description**

Five annotation tracks for plotting in Gviz.

**Usage**

```
data(axisTrack)
data(cpgIslands)
data(refGenes)
```

**Details**

These tracks are based on genome="danRer10", chr = "chr6", start = 24000000, end = 27000000.

**Examples**

```
data(axisTrack)
data(cpgIslands)
data(refGenes)
```

---

Axt-class

*Class "Axt"*


---

**Description**

The Axt S4 object to hold a axt file.

**Usage**

```
## Constructors:
Axt(targetRanges=GRanges(), targetSeqs=DNASTringSet(),
     queryRanges=GRanges(), querySeqs=DNASTringSet(),
     score=integer(0), symCount=integer(0), names=NULL)

## Accessor-like methods:
## S4 method for signature 'Axt'
targetRanges(x)
## S4 method for signature 'Axt'
targetSeqs(x)
## S4 method for signature 'Axt'
queryRanges(x)
## S4 method for signature 'Axt'
querySeqs(x)
## S4 method for signature 'Axt'
score(x)
## S4 method for signature 'Axt'
symCount(x)
## ... and more (see Methods)
```

**Arguments**

|                           |                                                                              |
|---------------------------|------------------------------------------------------------------------------|
| <code>targetRanges</code> | Object of class "GRanges": The ranges of net alignments on reference genome. |
| <code>targetSeqs</code>   | Object of class "DNASTringSet": The alignment sequences of reference genome. |
| <code>queryRanges</code>  | Object of class "GRanges": The ranges of net alignments on query genome.     |
| <code>querySeqs</code>    | Object of class "DNASTringSet": The alignment sequences of query genome.     |
| <code>score</code>        | Object of class "integer": The alignment score.                              |
| <code>symCount</code>     | Object of class "integer": The alignment length.                             |
| <code>names</code>        | <code>character()</code> : the names of axt alignments.                      |
| <code>x</code>            | Object of class "Axt": A Axt object.                                         |

**Details**

In 'axt' files and Axt object, the 'targetRanges' also have the alignments on positive strands. However, the 'queryRanges' can have alignments on negative strands, and the coordinates are based on negative strands, which is quite different from the convention in Bioconductor. To convert the coordinates of alignments on the negative strand to the positive strand, use `normaliseStrand`.

**Methods**

```
[ signature(x = "Axt", i = "ANY", j = "ANY"): Axt getter
c signature(x = "Axt"): Axt concatenator.
length signature(x = "Axt"): Get the number of alignments.
queryRanges signature(x = "Axt"): Get the ranges of query genome.
```

**querySeqs** signature(x = "Axt"): Get the alignment sequences of query genome.  
**score** signature(x = "Axt"): Get the alignment score.  
**symCount** signature(x = "Axt"): Get the alignment lengths.  
**targetRanges** signature(x = "Axt"): Get the ranges of reference genome.  
**targetSeqs** signature(x = "Axt"): Get the alignment sequences of reference genome.

### Author(s)

Ge Tan

### See Also

[readAxt](#) [writeAxt](#) [subAxt](#) [fixCoordinates](#) [makeAxtTracks](#)

### Examples

```
library(GenomicRanges)
library(Biostrings)
## Constructor
targetRanges <- GRanges(seqnames=c("chr1", "chr1", "chr2", "chr3"),
                        ranges=IRanges(start=c(1, 20, 2, 3),
                                       end=c(10, 25, 10, 10)),
                        strand="+")
targetSeqs <- DNAStringSet(c("ATTTTATGTG", "GGGAAG", "GGGCTTTTG",
                             "TTGTGTAG"))
queryRanges <- GRanges(seqnames=c("chr1", "chr10", "chr10", "chr20"),
                        ranges=IRanges(start=c(1, 25, 50, 5),
                                       end=c(10, 30, 58, 12)),
                        strand="+")
querySeqs <- DNAStringSet(c("ATTAAAGTG", "GGAAAA", "GGGCTCTGG",
                             "TTAAATAA"))
score <- c(246L, 4422L, 5679L, 1743L)
symCount <- c(10L, 6L, 9L, 8L)
axt <- Axt(targetRanges=targetRanges, targetSeqs=targetSeqs,
           queryRanges=queryRanges, querySeqs=querySeqs,
           score=score, symCount=symCount)

## getters
names(axt)
length(axt)
first(axt)
last(axt)
seqnames(axt)
strand(axt)
seqinfo(axt)

## Vector methods
axt[1]

## List methods
unlist(axt)
```

```
## Combining
c(axt, axt)
```

axtChain

*axtChain*

## Description

Wrapper function of axtChain: chain together psl alignments. If two matching alignments next to each other are close enough, they are joined into one segment. This function doesn't work on Windows platform since Kent utilities only support Unix-based platforms.

## Usage

```
axtChain(psls, chains=sub("\\.psl$", ".chain", psIs, ignore.case=TRUE),
         assemblyTarget, assemblyQuery,
         distance=c("far", "medium", "near"),
         removePsl=TRUE, binary="axtChain")
```

## Arguments

|                |                                                                                                                                                 |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| psls           | character(n): file names of input <i>psl</i> files.                                                                                             |
| chains         | character(n): file names of output <i>chain</i> files. By default, in the same folder of input lav files with same names.                       |
| assemblyTarget | character(1): the file name of target assembly <i>twoBit</i> file.                                                                              |
| assemblyQuery  | character(1): the file name of query assembly <i>twoBit</i> file.                                                                               |
| distance       | It can be "far", "medium" or "close". It decides the score matrix used in <i>lastz</i> aligner. See ' <i>?scoringMatrix</i> ' for more details. |
| removePsl      | boolean: When TRUE, the input <i>psl</i> files will be removed from the conversion.                                                             |
| binary         | character(1): the name/filename of the binary axtChain to call.                                                                                 |

## Value

character(n): the file names of output *chain* files.

## Author(s)

Ge Tan

## References

<http://hgdownload.cse.ucsc.edu/admin/exe/>

## See Also

[lavToPsl](#)

## Examples

```
## Not run:
## This example doesn't run because it requires two bit files and external
## Kent utilities.
psls <- tools::list_files_with_exts(
  dir="/Users/gtan/OneDrive/Project/CSC/CNEr/axt", exts="psl")
assemblyTarget <- "/Users/gtan/OneDrive/Project/CSC/CNEr/2bit/danRer10.2bit"
assemblyQuery <- "/Users/gtan/OneDrive/Project/CSC/CNEr/2bit/hg38.2bit"
axtChain(psls, assemblyTarget=assemblyTarget,
  assemblyQuery=assemblyQuery, distance="far",
  removePsl=FALSE, binary="axtChain")

## End(Not run)
```

---

axtInfo

*axtInfo function*


---

## Description

Given the path of the axt file, this function retrieves information on the widths of the alignments.

## Usage

```
axtInfo(axtFiles)
```

## Arguments

axtFiles            The filenames of axt files.

## Value

A vector of integer is returned. It stores the widths of all the alignments.

## Author(s)

Ge Tan

## See Also

[readAxt](#)

## Examples

```
axtFile <- file.path(system.file("extdata", package="CNEr"),
  "hg38.danRer10.net.axt")
axtInfo <- axtInfo(axtFile)
```



**Description**

Utility functions for UCSC bin indexing system manipulation

**Usage**

```
binFromCoordRange(starts, ends)
binRangesFromCoordRange(start, end)
binRestrictionString(start, end, field="bin")
```

**Arguments**

|              |                                                   |
|--------------|---------------------------------------------------|
| starts, ends | A vector of integers. A set of ranges.            |
| start, end   | A integer vector of length 1. A coordinate range. |
| field        | Name of bin column. Default: "bin".               |

**Details**

The UCSC bin indexing system was initially suggested by Richard Durbin and Lincoln Stein to speed up the SELECT of a SQL query for the rows overlapping with certain genome coordinate. The system first used in UCSC genome browser is described by Kent et. al. (2002).

**Value**

For binFromCoordRange, it returns the bin number that should be assigned to a feature spanning the given range. Usually it is used when creating a database for the features.

For binRangesFromCoordRange, it returns the set of bin ranges that overlap a given coordinate range. It is usually used to find out the bins overlapped with a range. For SQL query, it is more convenient to use binRestrictionString than to use this function directly.

For binRestrictionString, it returns a string to be used in the WHERE section of a SQL SELECT statement that is to select features overlapping a certain range. \* USE THIS WHEN QUERYING A DB \*

**Author(s)**

Ge Tan

**References**

Kent, W. J., Sugnet, C. W., Furey, T. S., Roskin, K. M., Pringle, T. H., Zahler, A. M., & Hausler, A. D. (2002). The Human Genome Browser at UCSC. *Genome Research*, 12(6), 996-1006. doi:10.1101/gr.229102

[http://genomewiki.ucsc.edu/index.php/Bin\\_indexing\\_system](http://genomewiki.ucsc.edu/index.php/Bin_indexing_system)

**Examples**

```
binFromCoordRange(starts=c(10003, 1000000), ends=c(10004, 1100000))
binRangesFromCoordRange(start=10000, end=2000000)
binRestrictionString(start=10000, end=2000000, field="bin")
```

---

blatCNE

*Wrapper function of blat for CNE object*


---

**Description**

This wrapper function blats the CNEs against the reference genome. Note that blat must be installed on your system.

**Usage**

```
blatCNE(cne, blatOptions=NULL, cutIdentity=90)
```

**Arguments**

|             |                                                                                                                         |
|-------------|-------------------------------------------------------------------------------------------------------------------------|
| cne         | cne object after cneMerge step.                                                                                         |
| blatOptions | character(1): the blat options. When it is NULL, the options will be chosen based on the window size for scanning CNEs. |
| cutIdentity | integer(1): the minimum sequence identity (in percent) for a match in blat. By default, it is 90.                       |

**Details**

When winSize > 45, the blat option is "-tileSize=11 -minScore=30 -repMatch=1024".

When 35 < winSize <= 45, the blat option is "-tileSize=10 -minScore=28 -repMatch=4096".

When the winSize <= 35, the blat option is "-tileSize=9 -minScore=24 -repMatch=16384".

**Value**

A CNE object with a final set of CNEs.

**Author(s)**

Ge Tan

## Examples

```
## Not run:
data(CNEDanRer10Hg38)
data(CNEHg38DanRer10)
cne <- CNE(assembly1Fn=file.path(system.file("extdata",
                                             package="BSgenome.Drerio.UCSC.danRer10"),
                                "single_sequences.2bit"),
          assembly2Fn=file.path(system.file("extdata",
                                             package="BSgenome.Hsapiens.UCSC.hg38"),
                                "single_sequences.2bit"),
          window=50L, identity=45L, CNE12=CNEDanRer10Hg38[["45_50"]],
          CNE21=CNEHg38DanRer10[["45_50"]], aligner="blat")
cne <- cneMerge(cne)
cne <- blatCNE(cne)

## End(Not run)
```

ceScan-methods

*ceScan function*

## Description

This is the main function for conserved noncoding elements (CNEs) identification.

## Usage

```
ceScan(x, tFilter=NULL, qFilter=NULL,
       tSizes=NULL, qSizes=NULL, window=50L, identity=50L)
```

## Arguments

|                               |                                                                                                                                                              |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>                | CNE object, or Axt object, or character(n) object of Axt filenames.                                                                                          |
| <code>tFilter, qFilter</code> | GRanges object or NULL: regions to filter out for target and query assembly.                                                                                 |
| <code>tSizes, qSizes</code>   | Seqinfo object or integer(n) or NULL: it contains the seqnames and seqlengths for target and query genome. When it's NULL, this 'seqinfo' must exist in 'x'. |
| <code>window</code>           | integer(n): the window size of scanning CNEs. By default, it is 50L.                                                                                         |
| <code>identity</code>         | integer(n): the minimal identity score over the scanning window. By default, it is 50L.                                                                      |

## Details

ceScan scan the axts alignments and identify the CNEs. ceScan can accept axts in Axt object and regions to filter out as GRanges objects, or directly the 'axt' files and 'bed' files.

The details of the algorithm are described in the vignette.

**Value**

A list of GRangePairs or CNE object is returned. Each element of the list corresponds to one user-specified threshold for identifying CNEs.

**Author(s)**

Ge Tan

**Examples**

```
library(BSgenome.Drerio.UCSC.danRer10)
library(BSgenome.Hsapiens.UCSC.hg38)
axtFnHg38DanRer10 <- file.path(system.file("extdata", package="CNEr"),
                               "hg38.danRer10.net.axt")
axtHg38DanRer10 <- readAxt(axtFnHg38DanRer10)
axtFnDanRer10Hg38 <- file.path(system.file("extdata", package="CNEr"),
                               "danRer10.hg38.net.axt")
axtDanRer10Hg38 <- readAxt(axtFnDanRer10Hg38)
bedHg38Fn <- file.path(system.file("extdata", package="CNEr"),
                       "filter_regions.hg38.bed")
bedHg38 <- readBed(bedHg38Fn)
bedDanRer10Fn <- file.path(system.file("extdata", package="CNEr"),
                           "filter_regions.danRer10.bed")
bedDanRer10 <- readBed(bedDanRer10Fn)
qSizesHg38 <- seqinfo(BSgenome.Hsapiens.UCSC.hg38)
qSizesDanRer10 <- seqinfo(BSgenome.Drerio.UCSC.danRer10)

## Axt object
windows <- c(50L, 50L, 50L)
identities <- c(45L, 48L, 49L)
CNEHg38DanRer10 <- ceScan(x=axtHg38DanRer10, tFilter=bedHg38,
                         qFilter=bedDanRer10,
                         tSizes=qSizesHg38, qSizes=qSizesDanRer10,
                         window=windows, identity=identities)
CNEDanRer10Hg38 <- ceScan(x=axtDanRer10Hg38, tFilter=bedDanRer10,
                         qFilter=bedHg38,
                         tSizes=qSizesDanRer10, qSizes=qSizesHg38,
                         window=windows, identity=identities)

## CNE object
cneDanRer10Hg38 <- CNE(
  assembly1Fn=file.path(system.file("extdata",
                                    package="BSgenome.Drerio.UCSC.danRer10"),
                        "single_sequences.2bit"),
  assembly2Fn=file.path(system.file("extdata",
                                    package="BSgenome.Hsapiens.UCSC.hg38"),
                        "single_sequences.2bit"),
  axt12Fn=axtFnDanRer10Hg38, axt21Fn=axtFnHg38DanRer10,
  cutoffs1=8L, cutoffs2=4L)
## Here danRer10Filter is tFilter since danRer10 is assembly1
cneListDanRer10Hg38 <- ceScan(x=cneDanRer10Hg38, tFilter=bedDanRer10,
                              qFilter=bedHg38,
```

```
window=windows, identity=identities)
```

---

|                |                       |
|----------------|-----------------------|
| chainMergeSort | <i>chainMergeSort</i> |
|----------------|-----------------------|

---

## Description

Wrapper function of chainMergeSort: Combines sorted files into a larger sorted file. This function doesn't work on Windows platform since Kent utilities only support Linux and Unix platforms.

## Usage

```
chainMergeSort(chains, assemblyTarget, assemblyQuery,
               allChain=paste0(sub("\\.2bit$", "", basename(assemblyTarget),
                                   ignore.case=TRUE), "."),
               sub("\\.2bit$", "", basename(assemblyQuery),
                                   ignore.case=TRUE), ".all.chain"),
               removeChains=TRUE, binary="chainMergeSort")
```

## Arguments

|                |                                                                                         |
|----------------|-----------------------------------------------------------------------------------------|
| chains         | character(n): file names of input <i>chains</i> files.                                  |
| assemblyTarget | character(1): the file name of target assembly <i>twoBit</i> file.                      |
| assemblyQuery  | character(1): the file name of query assembly <i>twoBit</i> file.                       |
| allChain       | character(1): file names of merged <i>allChain</i> file.                                |
| removeChains   | boolean: When TRUE, the input <i>chains</i> files will be removed after the conversion. |
| binary         | character(1): the name/filename of the binary chainMergeSort to call.                   |

## Details

This *allChain* file is what we get from UCSC download, e.g., **hg19.danRer7.all.chain.gz**.

## Value

character(1): the file names of merged *allChain* file.

## Author(s)

Ge Tan

## References

<http://hgdownload.cse.ucsc.edu/admin/exe/>

**See Also**[axtChain](#)**Examples**

```
## Not run:
## This example doesn't run because it requires two bit files and external
## Kent utilities.
chains <- tools::list_files_with_exts(
  dir="/Users/gtan/OneDrive/Project/CSC/CNEr/axt", exts="chain")
assemblyTarget <- "/Users/gtan/OneDrive/Project/CSC/CNEr/2bit/danRer10.2bit"
assemblyQuery <- "/Users/gtan/OneDrive/Project/CSC/CNEr/2bit/hg38.2bit"
chainMergeSort(chains, assemblyTarget, assemblyQuery,
  allChain=file.path("/Users/gtan/OneDrive/Project/CSC/CNEr/axt",
    paste0(sub("\\.2bit$", "", basename(assemblyTarget),
      ignore.case=TRUE), "."),
    sub("\\.2bit$", "", basename(assemblyQuery),
      ignore.case=TRUE), ".all.chain")),
  removeChains=FALSE, binary="chainMergeSort")

## End(Not run)
```

chainNetSyntenic

*chainNetSyntenic***Description**

Wrapper function of *chainNetSyntenic*: Makes alignment nets out of chains and adds syntenic info to net. This function doesn't work on Windows platform since Kent utilities only support Linux and Unix platforms.

**Usage**

```
chainNetSyntenic(allPreChain, assemblyTarget, assemblyQuery,
  netSyntenicFile=paste0(sub("\\.2bit$", "",
    basename(assemblyTarget),
    ignore.case = TRUE), "."),
  sub("\\.2bit$", "",
    basename(assemblyQuery),
    ignore.case = TRUE),
  ".noClass.net"),
  binaryChainNet="chainNet", binaryNetSyntenic="netSyntenic")
```

**Arguments**

**allPreChain**      character(1): file names of input *allPreChain* file.

**assemblyTarget**   character(1): the file name of target assembly *twoBit* file.

**assemblyQuery**    character(1): the file name of query assembly *twoBit* file.

```

netSyntenicFile
    character(1): file names of output netSyntenicFile file.
binaryChainNet character(1): the name/filename of the binary chainNet to call.
binaryNetSyntenic
    character(1): the name/filename of the binary netSyntenic to call.

```

## Details

Add classification information using the database tables: actually this step is not necessary in this pipeline according to <http://blog.gmane.org/gmane.science.biology.ucscgenome.general/month=20130301>. The class information will only be used for Genome Browser. Since it needs some specific modification of the table names for certain species, we skip this step now. If this step is done, then the generated *class.net* is the gzipped net file that you see in UCSC Downloads area.

## Value

character(1): the file names of generated *net* file.

## Author(s)

Ge Tan

## References

<http://hgdownload.cse.ucsc.edu/admin/exe/>

## See Also

[chainPreNet](#)

## Examples

```

## Not run:
## This example doesn't run because it requires two bit files and external
## Kent utilities.
allPreChain <- file.path("/Users/gtan/OneDrive/Project/CSC/CNEr/axt",
                        "danRer10.hg38.all.pre.chain")
assemblyTarget <- "/Users/gtan/OneDrive/Project/CSC/CNEr/2bit/danRer10.2bit"
assemblyQuery <- "/Users/gtan/OneDrive/Project/CSC/CNEr/2bit/hg38.2bit"
chainNetSyntenic(allPreChain, assemblyTarget, assemblyQuery,
                 netSyntenicFile=file.path(
                     "/Users/gtan/OneDrive/Project/CSC/CNEr/axt",
                     paste0(sub("\\.2bit$", "",
                                basename(assemblyTarget),
                                ignore.case = TRUE), ". ",
                                sub("\\.2bit$", "",
                                basename(assemblyQuery),
                                ignore.case = TRUE),
                                ".noClass.net")),
                 binaryChainNet="chainNet", binaryNetSyntenic="netSyntenic")

## End(Not run)

```

chainPreNet

*chainPreNet***Description**

Wrapper function of chainPreNet: Removes chains that don't have a chance of being netted. This function doesn't work on Windows platform since Kent utilities only support Linux and Unix platforms.

**Usage**

```
chainPreNet(allChain, assemblyTarget, assemblyQuery,
            allPreChain=paste0(sub("\\.2bit$", "", basename(assemblyTarget),
                                   ignore.case = TRUE), "."),
            sub("\\.2bit$", "", basename(assemblyQuery),
                                   ignore.case = TRUE), ".all.pre.chain"),
            removeAllChain=TRUE, binary="chainPreNet")
```

**Arguments**

**allChain** character(1): file names of input *allChain* file.

**assemblyTarget** character(1): the file name of target assembly *twoBit* file.

**assemblyQuery** character(1): the file name of query assembly *twoBit* file.

**allPreChain** character(1): file names of merged *allPreChain* file.

**removeAllChain** boolean: When TRUE, the input *allChain* file will be removed after the conversion.

**binary** character(1): the name/filename of the binary chainPreNet to call.

**Value**

character(1): the file names of merged *allPreChain* file.

**Author(s)**

Ge Tan

**References**

<http://hgdownload.cse.ucsc.edu/admin/exe/>

**See Also**

[chainMergeSort](#)



## Examples

```
## Not run:
## This example doesn't run because it requires two bit files and external
## Kent utilities.
allChain <- file.path("/Users/gtan/OneDrive/Project/CSC/CNEr/axt",
                     "danRer10.hg38.all.chain")
assemblyTarget <- "/Users/gtan/OneDrive/Project/CSC/CNEr/2bit/danRer10.2bit"
assemblyQuery <- "/Users/gtan/OneDrive/Project/CSC/CNEr/2bit/hg38.2bit"
chainPreNet(allChain, assemblyTarget, assemblyQuery,
            allPreChain=file.path(
                "/Users/gtan/OneDrive/Project/CSC/CNEr/axt",
                paste0(sub("\\.2bit$", "",
                        basename(assemblyTarget),
                        ignore.case = TRUE), "."),
                sub("\\.2bit$", "",
                        basename(assemblyQuery),
                        ignore.case = TRUE),
                ".all.pre.chain")),
            removeAllChain=FALSE, binary="chainPreNet")

## End(Not run)
```

CNE-class

Class "CNE"

## Description

CNE class contains all the meta-data of CNEs, including the pair of assemblies, the thresholds, the intermediate and final CNE sets.

## Usage

```
### Constructors:
CNE(assembly1Fn=character(1), assembly2Fn=character(1),
    axt12Fn=character(), axt21Fn=character(),
    window=50L, identity=50L,
    CNE12=GRangePairs(), CNE21=GRangePairs(),
    CNEMerged=GRangePairs(), CNEFinal=GRangePairs(),
    aligner="blat", cutoffs1=4L, cutoffs2=4L)

### Accessor-like methods:
## S4 method for signature 'CNE'
thresholds(x)
## S4 method for signature 'CNE'
CNE12(x)
## S4 method for signature 'CNE'
CNE21(x)
## S4 method for signature 'CNE'
```

```

CNEMerged(x)
## S4 method for signature 'CNE'
CNEFinal(x)

## ... and more (see Methods)

```

### Arguments

|                          |                                                                                                                              |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------|
| assembly1Fn, assembly2Fn | Object of class "character": The twoBit filenames of assembly1, assembly2                                                    |
| axt12Fn, axt21Fn         | Object of class "character": The Axt filenames of assembly1 to assembly2, assembly2 to assembly1                             |
| window                   | Object of class "integer": The window size for scanning CNEs. By default, it is 50.                                          |
| identity                 | Object of class "integer": The identity over the window size for scanning CNEs. By default, it is 50.                        |
| CNE12                    | Object of class "GRangePairs": The preliminary CNEs from axt file with assembly1 as reference.                               |
| CNE21                    | Object of class "GRangePairs": The preliminary CNEs from axt file with assembly2 as reference.                               |
| CNEMerged                | Object of class "GRangePairs": The CNEs after merging CNE1 and CNE2.                                                         |
| CNEFinal                 | Object of class "GRangePairs": The CNEs after being realigned back to reference genome, with blat in current implementation. |
| aligner                  | Object of class "character": The method to realign CNEs back to the reference genome.                                        |
| cutoffs1, cutoffs2       | Object of class "integer": The CNEs with more than the cutoff hits on the reference genome are removed.                      |
| x                        | Object of class "CNE": A "CNE" object.                                                                                       |

### Methods

**CNE12** signature(x = "CNE"): Get the CNE1 results.

**CNE21** signature(x = "CNE"): Get the CNE2 results.

**CNEMerged** signature(x = "CNE"): Get the merged CNE results.

**CNEFinal** signature(x = "CNE"): Get the final CNE results.

**thresholds** signature(x = "CNE"): Get the thresholds used for scanning CNEs.

### Author(s)

Ge Tan

**Examples**

```

library(GenomicRanges)
## Constructor
CNE12 <- GRangePairs(first=GRanges(seqnames=c("chr13", "chr4", "chr4"),
                                   ranges=IRanges(start=c(71727138, 150679343,
                                                         146653164),
                                                  end=c(71727224, 150679400,
                                                         146653221)),
                    strand="+"),
second=GRanges(seqnames=c("chr1"),
               ranges=IRanges(start=c(29854162, 23432387,
                                         35711077),
                              end=c(29854248, 23432444,
                                       35711134)),
               strand="+")
)
CNE21 <- GRangePairs(first=GRanges(seqnames=c("chr1"),
                                   ranges=IRanges(start=c(29854162, 23432387,
                                                         35711077),
                                                  end=c(29854248, 23432444,
                                                         35711134)),
                    strand="+"),
second=GRanges(seqnames=c("chr13", "chr4", "chr4"),
               ranges=IRanges(start=c(71727138, 150679343,
                                         146653164),
                              end=c(71727224, 150679400,
                                       146653221)),
               strand="+")
)
cne <- CNE(assembly1Fn=file.path(system.file("extdata",
                                             package="BSgenome.Drerio.UCSC.danRer10"),
                                "single_sequences.2bit"),
          assembly2Fn=file.path(system.file("extdata",
                                             package="BSgenome.Hsapiens.UCSC.hg38"),
                                "single_sequences.2bit"),
          window=50L, identity=50L,
          CNE12=CNE12, CNE21=CNE21, CNEMerged=CNE12, CNEFinal=CNE12,
          aligner="blat", cutoffs1=4L, cutoffs2=4L)

## Accessor
CNE12(cne)
CNE21(cne)
thresholds(cne)
CNEMerged(cne)
CNEFinal(cne)

```

**Description**

These two datasets are the direct output from ceScan.

**Usage**

```
data(CNEHg38DanRer10)
```

**Examples**

```
data(CNEHg38DanRer10)
```

---

|                    |                            |
|--------------------|----------------------------|
| CNEDensity-methods | <i>CNEDensity function</i> |
|--------------------|----------------------------|

---

**Description**

This function queries the database and generates the CNEs' density values.

**Usage**

```
CNEDensity(dbName, tableName, chr, start, end,
            whichAssembly=c("first", "second"),
            windowSize=300, minLength=NULL)
```

**Arguments**

|               |                                                                                                                                  |
|---------------|----------------------------------------------------------------------------------------------------------------------------------|
| dbName        | character(1): the path of the local SQLite database.                                                                             |
| tableName     | character(1): the name of table for this CNE data table. It can be missing when assembly1, assembly2 and threshold are provided. |
| chr           | character(1): the chromosome to query.                                                                                           |
| start, end    | integer(1): the start and end coordinate to fetch the CNEs.                                                                      |
| whichAssembly | character(1): the genome to fetch is in the 'first' column or 'second' column of the table.                                      |
| windowSize    | integer(1): the window size in kb that is used to smooth the CNEs.                                                               |
| minLength     | integer(1): the minimal length of CNEs to fetch.                                                                                 |

**Value**

A GRanges object with density values is returned.

**Methods**

```
signature(tableName = "character", assembly1 = "character", assembly2 = "missing", threshold = "missing")

signature(tableName = "missing", assembly1 = "character", assembly2 = "character", threshold = "character")
```

**Author(s)**

Ge Tan

**Examples**

```

dbName <- file.path(system.file("extdata", package="CNEr"),
                      "danRer10CNE.sqlite")
genome <- "danRer10"
chr <- "chr6"
start <- 24000000L
end <- 27000000L
windowSize <- 200L
minLength <- 50L
cneDanRer10Hg38_45_50 <-
  CNEDensity(dbName=dbName,
             tableName="danRer10_hg38_45_50",
             whichAssembly="first", chr=chr, start=start,
             end=end, windowSize=windowSize,
             minLength=minLength)
cneDanRer10Hg38_49_50 <-
  CNEDensity(dbName=dbName,
             tableName="danRer10_hg38_49_50",
             whichAssembly="first", chr=chr, start=start,
             end=end, windowSize=windowSize,
             minLength=minLength)

```

---

cneFinalListDanRer10Hg38

*cneFinalListDanRer10Hg38 dataset*


---

**Description**

cneFinalListDanRer10Hg38 dataset contains the CNE between danRer10 and hg38 around chr6:24,000,000..27,000,000.

**Usage**

```
data("cneFinalListDanRer10Hg38")
```

**Examples**

```
data(cneFinalListDanRer10Hg38)
```

---

|                  |                           |
|------------------|---------------------------|
| cneMerge-methods | <i>CNE merge function</i> |
|------------------|---------------------------|

---

**Description**

Removes the CNEs which overlap on both genomes.

**Usage**

```
cneMerge(cne12, cne21)
```

**Arguments**

|       |                                                                                   |
|-------|-----------------------------------------------------------------------------------|
| cne12 | A object of CNE or GRangePairs.                                                   |
| cne21 | A object of GRangePairs object. When cne12 is a CNE object, cne21 can be missing. |

**Value**

A GRangePairs of CNEs or a CNE object is returned. In this table, the order of columns is consistent with cne1. For instance, if cne1 has the first three columns for zebrafish and next three columns for human, in the merged table, the first three columns are still the coordinates for zebrafish while the next three columns are the coordinates for human.

**Author(s)**

Ge Tan

**Examples**

```
library(GenomicRanges)
firstGRange <- GRanges(seqnames=c("chr1", "chr1", "chr2", "chr2", "chr5"),
  ranges=IRanges(start=c(1, 20, 2, 3, 1),
    end=c(10, 25, 10, 10, 10)),
  strand="+")
lastGRange <- GRanges(seqnames=c("chr15", "chr10", "chr10", "chr10", "chr15"),
  ranges=IRanges(start=c(1, 25, 50, 51, 5),
    end=c(8, 40, 55, 60, 10)),
  strand="+")
cne12 <- GRangePairs(firstGRange[1:3], lastGRange[1:3])
cne21 <- GRangePairs(lastGRange[4:5], firstGRange[4:5])

## GRangePairs, GRangePairs
cneMerge(cne12, cne21)

## CNE, missing
cne <- CNE(assembly1Fn=file.path(system.file("extdata",
  package="BSgenome.Drerio.UCSC.danRer10"),
  "single_sequences.2bit"),
```

```
assembly2Fn=file.path(system.file("extdata",
                                package="BSgenome.Hsapiens.UCSC.hg38"),
                      "single_sequences.2bit"),
window=50L, identity=50L,
CNE12=cne12, CNE21=cne21, aligner="blat")
cneMerge(cne)
```

---

|                 |                                  |
|-----------------|----------------------------------|
| fetchChromSizes | <i>fetchChromSizes function.</i> |
|-----------------|----------------------------------|

---

## Description

This function tries to automate the fetch of chromosome sizes for assemblies from UCSC.

## Usage

```
fetchChromSizes(assembly)
```

## Arguments

assembly      A character object: the canonical name of assembly, i.e., 'hg19' for UCSC.

## Details

This function downloads 'chromInfo.txt.gz' from UCSC golden path for UCSC assemblies.

## Value

A object of Seqinfo is returned.

## Note

Currently, the assemblies from UCSC are supported.

## Author(s)

Ge Tan

## Examples

```
fetchChromSizes("hg19")
fetchChromSizes("mm10")
```

---

|                |                                          |
|----------------|------------------------------------------|
| fixCoordinates | <i>Fix the coordinates in Axt object</i> |
|----------------|------------------------------------------|

---

## Description

In ‘axt’ file and Axt object, the coordinates of negative query alignments are relative to the reverse-complemented coordinates of its chromosome. This is different from the convention in Bioconductor. This function fixes the coordinates which are always relative to the positive strand.

## Usage

```
fixCoordinates(x)
```

## Arguments

x                      Axt object.

## Details

In Axt, the ‘strand’ is for the aligning organism. If the strand value is “-”, the values of the aligning organism’s start and end fields are relative to the reverse-complemented coordinates of its chromosome.

## Value

A Axt object.

## Author(s)

Ge Tan

## Examples

```
axtFnDanRer10Hg38 <- file.path(system.file("extdata", package="CNEr"),
                               "danRer10.hg38.net.axt")
qAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Hsapiens.UCSC.hg38"),
                          "single_sequences.2bit")
tAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Drerio.UCSC.danRer10"),
                          "single_sequences.2bit")
axtDanRer10Hg38 <- readAxt(axtFnDanRer10Hg38, tAssemblyFn=tAssemblyFn,
                           qAssemblyFn=qAssemblyFn)

## Fix the coordinates
fixCoordinates(axtDanRer10Hg38)

## Restore it
fixCoordinates(fixCoordinates(axtDanRer10Hg38))
```



---

|                   |                            |
|-------------------|----------------------------|
| GRangePairs-class | <i>GRangePairs objects</i> |
|-------------------|----------------------------|

---

## Description

The GRangePairs class is a container for a pair of GRanges objects that have the same lengths.

## Details

A GRangePairs object is a list-like object where each element describes a pair of genomic range. They do not necessarily have the same seqinfo, *i.e.*, the coordinates from the same assembly.

## Constructor

`GRangePairs(first=GRanges(), second=GRanges(), ..., names=NULL, hits=NULL)`: GRangePairs constructor.

## Accessors

In the code snippets below, `x` is a GRangePairs object.

`length(x)`: Return the number of granges pairs in `x`.

`names(x)`, `names(x) <- value`: Get or set the names on `x`.

`first(x)`, `last(x)`, `second(x)`: Get the 'first' or 'last'/'second' GRRange for each grange pair in `x`. The result is a [GRanges](#) object of the same length as `x`.

`first(x)<-`, `second(x)<-`: Set the 'first' or 'second' GRRange for each grange pair in `x`. The result is a [GRanges](#) object of the same length as `x`.

`seqnames(x)`: Get the seqname of first GRanges and last GRanges and return in a DataFrame object.

`strand(x)`: Get the strand for each grange pair in `x`.

`seqinfo(x)`: Get the information about the underlying sequences.

## Vector methods

In the code snippets below, `x` is a GRangePairs object.

`x[i]`: Return a new GRangePairs object made of the selected genomic ranges pairs.

## List methods

In the code snippets below, `x` is a GRangePairs object.

`unlist(x, use.names=TRUE)`: Return the [GRangePairs](#) object conceptually defined by `c(x[[1]], x[[2]], ..., x[[length(x)]])`. `use.names` determines whether `x` names should be passed to the result or not.

## Coercion

In the code snippets below, `x` is a `GRangePairs` object.

```
grglist(x, use.mcols=FALSE):
```

Return a `GRangesList` object of length `length(x)` where the *i*-th element represents the ranges (with respect to the reference) of the *i*-th grange pair in `x`.

Note that this results in the ranges being *always* ordered consistently with the original "query template", that is, being in the order defined by walking the "query template" from the beginning to the end.

If `use.mcols` is `TRUE` and `x` has metadata columns on it (accessible with `mcols(x)`), they're propagated to the returned object.

```
as(x, "GRangesList"): Alternate ways of doing grglist(x, use.mcols=TRUE).
```

```
as(x, "GRanges"): Equivalent of unlist(x, use.names=TRUE).
```

## Other methods

In the code snippets below, `x` is a `GRangesList` object.

```
swap(x): Swap the first, last GRanges.
```

```
unique(x): Get the unique GRangePairs.
```

```
show(x): By default, the show method displays 5 head and 5 tail elements. This can be changed by setting the global options showHeadLines and showTailLines. If the object length is less than (or equal to) the sum of these 2 options plus 1, then the full object is displayed.
```

## Author(s)

Ge Tan

## See Also

[Axt](#)

## Examples

```
## Constructor
library(GenomicRanges)
first <- GRanges(seqnames=c("chr1", "chr1", "chr2", "chr3"),
                 ranges=IRanges(start=c(1, 20, 2, 3),
                                end=c(10, 25, 10, 10)),
                 strand="+")
last <- GRanges(seqnames=c("chr1", "chr10", "chr10", "chr20"),
                 ranges=IRanges(start=c(1, 25, 50, 5),
                                end=c(8, 40, 55, 16)),
                 strand="+")
namesGRangePairs <- c("a", "b", "c", "d")
grangesPairs1 <- GRangePairs(first, last, names=namesGRangePairs)
grangesPairs2 <- GRangePairs(first, last)

## getters and setters
```

```

names(grangesPairs1)
names(grangesPairs2) <- namesGRangePairs

first(grangesPairs1)
first(grangesPairs1) <- second(grangesPairs1)

second(grangesPairs1)
second(grangesPairs1) <- first(grangesPairs1)

length(grangesPairs1)
seqnames(grangesPairs1)
strand(grangesPairs1)
seqinfo(grangesPairs1)

## Vector methods
grangesPairs1[1]

## List methods
unlist(grangesPairs1)

## Coersion
grglist(grangesPairs1)
as(grangesPairs1, "GRangesList")
as(grangesPairs1, "GRanges")
as(grangesPairs1, "DataFrame")
as.data.frame(grangesPairs1)

## Combining
c(grangesPairs1, grangesPairs2)

## Swap
swap(grangesPairs1)

## Unique
unique(c(grangesPairs1, grangesPairs1))

```

---

grangesPairsForDotplot

*grangesPairsForDotplot*


---

### Description

Example of GrangePairs object from the collinear regions of *Adineta vaga*.

### Usage

```
data("grangesPairsForDotplot")
```

### Details

The collinear regions from “scaffold\_1” and “scaffold\_5”.

Source

Example from own project.

Examples

```
data(grangesPairsForDotplot)
```

---

|        |                       |
|--------|-----------------------|
| lastal | <i>lastal wrapper</i> |
|--------|-----------------------|

---

Description

Wrapper function of lastal to do the pairwise whole genome alignment. This function doesn't work on Windows platform.

Usage

```
lastal(db, queryFn,
       outputFn=sub("\\.(fa|fasta)$", ".maf",
                    paste(basename(db), basename(queryFn), sep = ","),
                    ignore.case = TRUE),
       distance=c("far", "medium", "near"), binary="lastal",
       mc.cores=getOption("mc.cores", 2L), echoCommand=FALSE)
```

Arguments

- db                    character(1): the file name of target assembly's lastal index.
- queryFn             character(1): the file name of query assembly *fasta* file.
- outputFn            character(1): the file name of the output *maf* file.
- distance            It can be "far", "medium" or "near". It decides the score matrix used in *lastz* aligner. See '?scoringMatrix' for more details.
- binary              character(1): the name/filename of the binary lastal to call.
- mc.cores            integer(1): the number of threads to use. By default, getOption("mc.cores", 2L).
- echoCommand        boolean(1): When TRUE, only the command to run lastal is returned.

Value

A character(1) vector of ouput *maf* file names.

Note

lastal aligner must be installed on the machine to use this function.

**Author(s)**

Ge Tan

**References**<http://last.cbrc.jp/>**See Also**[lastz](#)**Examples**

```
## Not run:
assemblyDir <- "/Users/gtan/OneDrive/Project/CSC/CNER/2bit"
## Build the lastdb index
system2(command="lastdb", args=c("-c", file.path(assemblyDir, "danRer10"),
                                              file.path(assemblyDir, "danRer10.fa")))

## Run lastal aligner
lastal(db=file.path(assemblyDir, "danRer10"),
      queryFn=file.path(assemblyDir, "hg38.fa"),
      outputFn=file.path(axtDir, "danRer10.hg38.maf"),
      distance="far", binary="lastal", mc.cores=4L)

## maf to psl
psls <- file.path(axtDir, "danRer10.hg38.psl")
system2(command="maf-convert",
      args=c("psl", file.path(axtDir, "danRer10.hg38.maf"),
            ">", psls))

## End(Not run)
```

lastz

*lastz wrapper***Description**

Wrapper function of lastz to do the pairwise whole genome alignment. This function doesn't work on Windows platform.

**Usage**

```
lastz(assemblyTarget, assemblyQuery, outputDir = ".",
      chrsTarget = NULL, chrsQuery = NULL,
      distance = c("far", "medium", "near"), binary = "lastz",
      mc.cores = getOption("mc.cores", 2L), echoCommand = FALSE)
```

**Arguments**

|                |                                                                                                                                       |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------|
| assemblyTarget | character(1): the file name of target assembly <i>twoBit</i> file.                                                                    |
| assemblyQuery  | character(1): the file name of query assembly <i>twoBit</i> file.                                                                     |
| outputDir      | character(1): the folder to put the generated <i>lav</i> files.                                                                       |
| chrsTarget     | NULL or character(n): when it's NULL, all the available chromosomes from the target assembly will be aligned.                         |
| chrsQuery      | NULL or character(n): when it's NULL, all the available chromosomes from the query assembly will be aligned.                          |
| distance       | It can be "far", "medium" or "near". It decides the score matrix used in <i>lastz</i> aligner. See '?scoringMatrix' for more details. |
| binary         | character(1): the name/filename of the binary <i>lastz</i> to call.                                                                   |
| mc.cores       | integer(1): the number of threads to use. By default, <code>getOption("mc.cores", 2L)</code> .                                        |
| echoCommand    | boolean(1): When TRUE, only the command to run <i>lastz</i> is returned.                                                              |

**Value**

A character(n) vector of output *lav* file names.

**Note**

*lastz* aligner must be installed on the machine to use this function.

**Author(s)**

Ge Tan

**References**

<http://www.bx.psu.edu/~rsharris/lastz/>

**See Also**

[lavToPsl](#)

**Examples**

```
## Not run:
## This example doesn't run because it requires two bit files and external
## Kent utilities.
assemblyTarget <- "/Users/gtan/OneDrive/Project/CSC/CNEr/2bit/danRer10.2bit"
assemblyQuery <- "/Users/gtan/OneDrive/Project/CSC/CNEr/2bit/hg38.2bit"
lavs <- lastz(assemblyTarget, assemblyQuery,
             outputDir="/Users/gtan/OneDrive/Project/CSC/CNEr/axt",
             chrsTarget=c("chr1", "chr2", "chr3"),
             chrsQuery=c("chr1", "chr2", "chr3"),
             distance="far", mc.cores=4)

## End(Not run)
```

---

|          |                 |
|----------|-----------------|
| lavToPsl | <i>lavToPsl</i> |
|----------|-----------------|

---

## Description

Wrapper function of `lavToPsl`: Convert blastz lav to psl format. This function doesn't work on Windows platform since Kent utilities only support Linux and Unix platforms.

## Usage

```
lavToPsl(lavs, psIs=sub("\\.lav$", ".psl", lavs, ignore.case = TRUE),
        removeLav=TRUE, binary="lavToPsl")
```

## Arguments

|                        |                                                                                                                                    |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| <code>lavs</code>      | character(n): file names of input <i>lav</i> files.                                                                                |
| <code>psIs</code>      | codecharacter(n): file names of output <i>psl</i> files. By default, in the same folder of input <i>lav</i> files with same names. |
| <code>removeLav</code> | boolean: When TRUE, the input <i>lavs</i> files will be removed after the conversion.                                              |
| <code>binary</code>    | character(1): the name/filename of the binary <code>lavToPsl</code> to call.                                                       |

## Value

character(n): the file names of output *psl* files.

## Author(s)

Ge Tan

## References

<http://hgdownload.cse.ucsc.edu/admin/exe/>

## See Also

[lastz](#)

## Examples

```
## Not run:
## This example doesn't run because it requires lav files from previous steps
## and external Kent utilities.
lavs <- tools::list_files_with_exts(
  dir="/Users/gtan/OneDrive/Project/CSC/CNEr/axt", exts="lav")
lavToPsl(lavs, removeLav=FALSE, binary="lavToPsl")

## End(Not run)
```

---

|                 |                        |
|-----------------|------------------------|
| makeAncoraFiles | <i>makeAncoraFiles</i> |
|-----------------|------------------------|

---

## Description

Make ancora format files from GRangePairs of CNE

## Usage

```
makeAncoraFiles(cne, outputDir = ".",  
                genomeFirst = "first", genomeSecond = "second",  
                threshold = "50_50")
```

## Arguments

|                           |                                                                                    |
|---------------------------|------------------------------------------------------------------------------------|
| cne                       | GRangePairs object of CNE.                                                         |
| outputDir                 | character(1): the output directory of 'Bed' and 'BigWig' files.                    |
| genomeFirst, genomeSecond | character(1): the genome name of the first and second species.                     |
| threshold                 | character(1): the threshold used to identify the CNEs in the format of "50_50" etc |

## Value

The filenames of output.

## Note

This function is mainly for internal use in Lenhard group.

## Author(s)

Ge Tan

## See Also

[readAncora](#)

## Examples

```
data(cneFinalListDanRer10Hg38)  
cne <- CNEFinal(cneFinalListDanRer10Hg38[["45_50"]])  
makeAncoraFiles(cne, genomeFirst = "danRer10", genomeSecond = "hg38",  
                threshold = "45_50")
```



---

makeAxtTracks

*makeAxtTracks*


---

## Description

Make the bed tracks for the ‘Axt’ alignment.

## Usage

```
makeAxtTracks(x)
```

## Arguments

x                      A Axt object.

## Details

The coordinates of query ‘Axt’ alignment are fixed to be relative to positive strand before output into ‘bed’ file.

## Value

A list of GRanges for target and query alignments. The two output ‘bed’ files are “targetAxt.bed” and “queryAxt.bed”.

## Author(s)

Ge Tan

## See Also

[fixCoordinates](#)

## Examples

```
tAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Drerio.UCSC.danRer10"),
                          "single_sequences.2bit")
qAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Hsapiens.UCSC.hg38"),
                          "single_sequences.2bit")
axtFn <- file.path(system.file("extdata", package="CNER"),
                  "danRer10.hg38.net.axt")
axt <- readAxt(axtFn, tAssemblyFn, qAssemblyFn)
makeAxtTracks(axt)
```

---

|                |                                                  |
|----------------|--------------------------------------------------|
| makeCNEDensity | <i>Make 'Bed', 'bedGraph' and 'BigWig' files</i> |
|----------------|--------------------------------------------------|

---

## Description

Make 'Bed', 'bedGraph', 'BigWig' files from GRangePairs for display in other Genome Browser.

## Usage

```
makeCNEDensity(x, outputDir = ".",  
               genomeFirst = "first", genomeSecond = "second",  
               threshold = "50_50",  
               windowSizeFirst = 300L, windowSizeSecond = 300L)
```

## Arguments

|                                   |                                                                             |
|-----------------------------------|-----------------------------------------------------------------------------|
| x                                 | GRangePairs object of CNEs.                                                 |
| outputDir                         | character(1): the output directory of 'Bed', 'bedGraph' and 'BigWig' files. |
| genomeFirst, genomeSecond         | character(1): the genome name of the first and second species.              |
| threshold                         | character(1): the threshold used to identify the CNEs in format of "50_50". |
| windowSizeFirst, windowSizeSecond | integer(1): the smoothing window size for generating the CNE density in kb. |

## Details

The CNE density is defined as the percentage of regions covered by CNEs within the smoothing window.

## Value

The filenames of output 'Bed', 'bedGraph' and 'BigWig' files.

## Note

This function is mainly for internal use in Lenhard group.

## Author(s)

Ge Tan

## See Also

[readAncora](#)

## Examples

```
## Not run:
dbName <- file.path(system.file("extdata", package="CNEr"),
                     "danRer10CNE.sqlite")
qAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Hsapiens.UCSC.hg38"),
                         "single_sequences.2bit")
tAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Drerio.UCSC.danRer10"),
                         "single_sequences.2bit")
cneGRangePairs <- readCNERangesFromSQLite(dbName=dbName,
                                         tableName="danRer10_hg38_45_50",
                                         tAssemblyFn=tAssemblyFn,
                                         qAssemblyFn=qAssemblyFn)

makeCNEDensity(cneGRangePairs[1:1000])

## End(Not run)
```

---

makeGRBs

*makeGRBs*


---

## Description

Make Genomic Regulatory Blocks (GRBs) boundaries prediction from a set of CNEs.

## Usage

```
makeGRBs(x, winSize=NULL, genes=NULL, ratio=1,
         background=c("chromosome", "genome"), minCNEs=1L)
```

## Arguments

|                         |                                                                                                                                                                                                                                                                                                                    |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>          | GRangesList object of a set of CNEs to use.                                                                                                                                                                                                                                                                        |
| <code>winSize</code>    | integer: the smoothing window size for CNE densities in kb. This value depends on the genome size of the reference genome. A larger genome requires bigger window size. For instance, 300kb is the appropriate window size for the human genome. By default, it is determined internally based on the genome size. |
| <code>genes</code>      | NULL or GRanges object: the protein-coding genes ranges.                                                                                                                                                                                                                                                           |
| <code>ratio</code>      | numeric(1): the threshold to control the stringency of the GRBs. Higher value, shorter and fewer GRBs, and vice versa.                                                                                                                                                                                             |
| <code>background</code> | character(1): can be "chromosome" or "genome". When using slice for the CNE density, the background is calculated on a per-chromosome or whole-genome basis.                                                                                                                                                       |
| <code>minCNEs</code>    | integer(1): the minimal number of CNEs that a GRB needs to have.                                                                                                                                                                                                                                                   |

### Details

First we calculate the CNE densities from the CNEs. Then we segment the regions according to the values of CNE densities. The regions with CNE densities above the expected CNE densities \* ratio are considered as putative GRBs. Putative GRBs that do not encompass any gene are filtered out. Finally, the GRBs that have fewer than minCNEs number of CNEs will be filtered out.

### Value

A GRanges object of GRB coordinates is returned. The numbers of CNEs and the coordinates of CNEs within each GRB are returned as a metadata column.

### Author(s)

Ge Tan

### Examples

```
library(TxDb.Drerio.UCSC.danRer10.refGene)
refGenesDanRer10 <- genes(TxDb.Drerio.UCSC.danRer10.refGene)
ancoraCNEsFns <- file.path(system.file("extdata", package="CNER"),
                           c("cne2wBf_cypCar1_danRer10_100_100",
                             "cne2wBf_cteIde1_danRer10_100_100",
                             "cne2wBf_AstMex102_danRer10_48_50"))
cneList <- do.call(GRangesList,
                  lapply(ancoraCNEsFns, readAncora, assembly="danRer10"))
names(cneList) <- c("Common carp", "Grass carp", "Blind cave fish")
seqlengths(cneList) <- seqlengths(TxDb.Drerio.UCSC.danRer10.refGene)[
  names(seqlengths(cneList))]
makeGRBs(cneList, winSize=200, genes=refGenesDanRer10, ratio=1.2,
         background="genome")
makeGRBs(cneList, winSize=200, genes=refGenesDanRer10, ratio=1.2,
         background="chromosome", minCNEs=3L)
```

---

|                   |                                                     |
|-------------------|-----------------------------------------------------|
| matchDistribution | <i>Plot the distribution of matched alignments.</i> |
|-------------------|-----------------------------------------------------|

---

### Description

Given a Axt alignment, plot a heatmap showing the percentage of each matched alignments.

### Usage

```
matchDistribution(x, size=10000, title=NULL)
```

### Arguments

|       |                                                                       |
|-------|-----------------------------------------------------------------------|
| x     | Axt object.                                                           |
| size  | integer(1): the number of alignments to use. By default, it is 10000. |
| title | character(1): the customised title for the plot.                      |

**Details**

By default, if there are more than 10,000 alignments, 10,000 alignments will be sampled and calculated for the distribution for speed purposes.

Only the four bases (A, C, G, T), gap (-) and any (N) are displayed. Other ambiguous bases are not considered.

**Value**

A ggplot2 object will be returned.

**Author(s)**

Ge Tan

**Examples**

```
axtFile <- file.path(system.file("extdata", package="CNEr"),
                      "hg38.danRer10.net.axt")
axt <- readAxt(axtFile)
matchDistribution(axt)
```

---

N50

*Assembly statistics.*

---

**Description**

Calculate the N50, N90 values for a fasta or 2bit file.

**Usage**

```
N50(fn)
N90(fn)
```

**Arguments**

fn                      character(1): The path of a fasta or 2bit file.

**Details**

This function calculates the N50, N90 values for an assembly. The N50 value is calculated by first ordering every contig/scaffold by length from longest to shortest. Next, starting from the longest contig/scaffold, the lengths of each contig are summed, until this running sum equals one-half of the total length of all contigs/scaffolds in the assembly. Then the length of shortest contig/scaffold in this list is the N50 value. Similar procedure is used for N90 but including 90% of the assembly.

**Value**

An integer value of N50 or N90 value.

**Author(s)**

Ge Tan

**Examples**

```
twoBitFn <- file.path(system.file("extdata",
                                package="BSgenome.Drerio.UCSC.danRer10"),
                      "single_sequences.2bit")
N50(twoBitFn)
```

---

netToAxt

*netToAxt*


---

**Description**

Wrapper function of netToAxt and axtSort: convert net (and chain) to axt, and sort axt files. This function doesn't work on the Windows platform since Kent utilities only support Linux and Unix platforms.

**Usage**

```
netToAxt(in.net, in.chain, assemblyTarget, assemblyQuery,
        axtFile=paste0(sub("\\.2bit$", "", basename(assemblyTarget),
                          ignore.case = TRUE), "."),
        sub("\\.2bit$", "", basename(assemblyQuery),
            ignore.case = TRUE), ".net.axt"),
        removeFiles=FALSE,
        binaryNetToAxt="netToAxt", binaryAxtSort="axtSort")
```

**Arguments**

|                |                                                                                                       |
|----------------|-------------------------------------------------------------------------------------------------------|
| in.net         | character(1): file names of input <i>net</i> file.                                                    |
| in.chain       | character(1): file names of input <i>chain</i> file.                                                  |
| assemblyTarget | character(1): the file name of target assembly <i>twoBit</i> file.                                    |
| assemblyQuery  | character(1): the file name of query assembly <i>twoBit</i> file.                                     |
| axtFile        | character(1): file names of output <i>axt</i> file.                                                   |
| removeFiles    | boolean: When TRUE, the input <i>net</i> and <i>chain</i> files will be removed after the conversion. |
| binaryNetToAxt | character(1): the name/filename of the binary netToAxt to call.                                       |
| binaryAxtSort  | character(1): the name/filename of the binary axtSort to call.                                        |

**Value**

character(1): the file name of output *axt* file.

**Author(s)**

Ge Tan

**References**<http://hgdownload.cse.ucsc.edu/admin/exe/>**See Also**[chainNetSyntenic](#)**Examples**

```
## Not run:
## This example doesn't run because it requires two bit files and external
## Kent utilities.
in.net <- file.path("/Users/gtan/OneDrive/Project/CSC/CNEr/axt",
                  "danRer10.hg38.noClass.net")
in.chain <- file.path("/Users/gtan/OneDrive/Project/CSC/CNEr/axt",
                    "danRer10.hg38.all.pre.chain")
assemblyTarget <- "/Users/gtan/OneDrive/Project/CSC/CNEr/2bit/danRer10.2bit"
assemblyQuery <- "/Users/gtan/OneDrive/Project/CSC/CNEr/2bit/hg38.2bit"
netToAxt(in.net, in.chain, assemblyTarget, assemblyQuery,
        axtFile=file.path("/Users/gtan/OneDrive/Project/CSC/CNEr/axt",
                          paste0(sub("\\.2bit$", "",
                                     basename(assemblyTarget),
                                     ignore.case = TRUE), "."),
                          sub("\\.2bit$", "",
                                     basename(assemblyQuery),
                                     ignore.case = TRUE),
                          ".net.axt")),
        removeFiles=FALSE,
        binaryNetToAxt="netToAxt", binaryAxtSort="axtSort")

## End(Not run)
```

---

orgKEGGIds2EntrezIDs    *Fetch mapping from KEGG IDs to Entrez IDs*

---

**Description**

Given the desired organism name, fetch the mapping between KEGG IDs and Entrez gene IDs.

**Usage**

```
orgKEGGIds2EntrezIDs(organism="Homo sapiens")
```

**Arguments**

organism                      character(1): the name of organism to query. It has to be available at <http://rest.kegg.jp/list/organism>.

**Value**

A list of Entrez gene IDs with KEGG IDs as names.

**Author(s)**

Ge Tan

**Examples**

```
## Not run:
  orgKEGGIds2EntrezIDs(organism="Homo sapiens")

## End(Not run)
```

---

plotCNEDistribution     *Plot sequential CNE number against CNE genomic location*

---

**Description**

Plot the CNE genomic location distribution. It gives an overview of the tendency of CNEs to form clusters.

**Usage**

```
plotCNEDistribution(x, chrs = NULL, chrScale = c("Mb", "Kb"))
```

**Arguments**

|          |                                                                                                      |
|----------|------------------------------------------------------------------------------------------------------|
| x        | GRanges object: the CNE locations.                                                                   |
| chrs     | character(n): the chromosomes to show. By default, the largest 6 chromosomes/scaffolds are selected. |
| chrScale | character(1): the chromosome/scaffold scale of 'Mb' or 'Kb' in the plot.                             |

**Details**

In the plot, x axis is the genomic location along each chromosome/scaffold. The y axis is the sequential CNE number. A typical CNE cluster can be spotted by the dramatic increase in y axis and small increase in x axis.

**Value**

A ggplot object.

**Author(s)**

Ge Tan



**See Also**[plotCNEWidth](#)**Examples**

```

dbName <- file.path(system.file("extdata", package="CNEr"),
                     "danRer10CNE.sqlite")
qAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Hsapiens.UCSC.hg38"),
                         "single_sequences.2bit")
tAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Drerio.UCSC.danRer10"),
                         "single_sequences.2bit")
cneGRangePairs <- readCNERangesFromSQLite(dbName=dbName,
                                         tableName="danRer10_hg38_45_50",
                                         tAssemblyFn=tAssemblyFn,
                                         qAssemblyFn=qAssemblyFn)

plotCNEDistribution(first(cneGRangePairs))

```

plotCNEWidth

*Plot the CNE widths distribution***Description**

CNE widths can follow heavy tailed distribution that are associated with power-laws. This function plots the reverse cumulative density distribution of CNE widths, and fits a discrete power-law distribution. Goodness of fit can also be evaluated.

**Usage**

```
plotCNEWidth(x, ...)
```

**Arguments**

**x** GRangePairs object: a pair of CNEs.

**...** Additional points passed to plot function.

**Details**

The power-law distribution is associated with heavy tailed distribution.

A reverse cumulative density distribution plot will be generated with optimal lower bound *xmin*, scaling parameter *alpha* for power-law fit.

**Value**

An invisible list of fitted model is returned.

**Note**

The power-law distribution implementation is based on the **powerLaw** package.

**Author(s)**

Ge Tan

**References**

Salerno, W., Havlak, P., and Miller, J. (2006). Scale-invariant structure of strongly conserved sequence in genomic intersections and alignments. *Proc. Natl. Acad. Sci. U.S.A.* 103, 13121-13125.

**Examples**

```
dbName <- file.path(system.file("extdata", package="CNEr"),
                      "danRer10CNE.sqlite")
cneGRangePairs <- readCNERangesFromSQLite(dbName=dbName,
                                          tableName="danRer10_hg38_45_50")
plotCNEWidth(cneGRangePairs)
```

---

psubAxt

---

*Parallel subset of Axt alignment*


---

**Description**

Given two GRanges objects, select the Axt alignments whose the target and query alignments are both within each pair of ranges.

**Usage**

```
psubAxt(x, targetSearch, querySearch)
```

**Arguments**

**x** Axt object.

**targetSearch, querySearch** GRanges objects: the ranges to keep for target and query alignments. They must be of the same length. Strand information is ignored.

**Details**

The ‘targetSearch’ and ‘querySearch’ have the coordinates relative to the positive strand. For each pair of the ranges, the alignments that lie within both the target and query range are kept.

**Value**

A Axt object.

**Author(s)**

Ge Tan

**See Also**[psubAxt](#)**Examples**

```

library(GenomicRanges)
tAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Drerio.UCSC.danRer10"),
                         "single_sequences.2bit")
qAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Hsapiens.UCSC.hg38"),
                         "single_sequences.2bit")
axtFn <- file.path(system.file("extdata", package="CNEr"),
                  "danRer10.hg38.net.axt")
axt <- readAxt(axtFn, tAssemblyFn, qAssemblyFn)

targetSearch <- GRanges(seqnames=c("chr6"),
                       ranges=IRanges(start=c(24000000, 26900000),
                                       end=c(24060000, 26905000)),
                       strand="+")
querySearch <- GRanges(seqnames=c("chr7", "chr2"),
                      ranges=IRanges(start=c(12577000, 241262700),
                                      end=c(12579000, 241268600)),
                      strand="+")
psubAxt(axt, targetSearch, querySearch)

```

queryCNEData

*Query the CNEData package to fetch the CNEs***Description**

Query the CNEData package to fetch the CNEs based on target, query species, winSize and identity.

**Usage**

```

queryCNEData(dbName, target, query, winSize, identity,
             type=c("target", "all"))

```

**Arguments**

|                   |                                                                                                                      |
|-------------------|----------------------------------------------------------------------------------------------------------------------|
| dbName            | The path of SQLite database.                                                                                         |
| target, query     | The CNEs between target and query species.                                                                           |
| winSize, identity | The thresholds of CNEs to fetch on identity over winSize.                                                            |
| type              | Which set of CNEs are returned. When it is "all", the CNEs of target always on the left side of returned data.frame. |

**Value**

A data.frame of CNEs coordinates in chr, start, end.

**Author(s)**

Ge Tan

---

read.rmMask.GRanges     *Read a RepeatMasker .out file*

---

**Description**

Read a RepeatMasker .out file into a GRanges object.

**Usage**

```
read.rmMask.GRanges(fn)
```

**Arguments**

fn                      character(1): the filename of a RepeatMasker .out file.

**Value**

A GRanges object with metadata columns containing the name of the matching interspersed repeat, the class of the repeat and the Smith-Waterman score of the match.

**Author(s)**

Ge Tan

**References**

<http://www.repeatmasker.org/webrepeatmaskerhelp.html>

**Examples**

```
fn <- system.file("extdata", "ce2chrM.fa.out", package="IRanges")
read.rmMask.GRanges(fn)
```

---

|                |                                        |
|----------------|----------------------------------------|
| read.rmskFasta | <i>Read a soft repeat masked fasta</i> |
|----------------|----------------------------------------|

---

## Description

Read a soft repeat masked fasta file into a GRanges object.

## Usage

```
read.rmskFasta(fn)
```

## Arguments

fn                      character(1): The filename of the soft repeat masked fasta.

## Details

Only the lower case based ("a", "c", "g", "t") are considered in the soft repeat masked fasta.

## Value

GRanges object with coordinates of repeat masked regions.

## Author(s)

Ge Tan

## See Also

[read.rmMask.GRanges](#)

## Examples

```
fn <- file.path(system.file("extdata", package="CNEr"),  
                 "rmsk.fa")  
read.rmskFasta(fn)
```

---

|            |                                              |
|------------|----------------------------------------------|
| readAncora | <i>Read the cne file from Ancora format.</i> |
|------------|----------------------------------------------|

---

## Description

Read the Ancora CNE file into a GRanges or GRangePairs object.

## Usage

```
readAncora(fn, assembly=NULL, tAssemblyFn=NULL, qAssemblyFn=NULL)
```

## Arguments

|                          |                                                                                             |
|--------------------------|---------------------------------------------------------------------------------------------|
| fn                       | character(1): the path of the Ancora CNE file in the format of "cne2wBf_hg38_mm10_50_50".   |
| assembly                 | character(1): the assembly to fetch. When it is NULL, CNEs on both assemblies are returned. |
| tAssemblyFn, qAssemblyFn | character(1): filename of the 'twoBit' or 'fasta' file for the target and query genomes.    |

## Details

The Ancora CNE filename has its own naming style. For example, "cne2wBf\_hg38\_mm10\_50\_50" denotes human coordinates for the first three columns of the file and mouse coordinates from the forth to the sixth column.

The start coordinate system is 0-based.

## Value

A GRanges object of the CNE ranges when assembly is specified, or a GRangePairs object when assembly is NULL.

## Note

This function is mainly for internal use in Lenhard group.

## Author(s)

Ge Tan

## Examples

```
fn <- file.path(system.file("extdata", package="CNEr"),
                  "cne2wBf_danRer10_hg38_45_50")
zebrafishCNEs <- readAncora(fn, "danRer10")
humanCNEs <- readAncora(fn, "hg38")
zebrafishHumanCNEs <- readAncora(fn)
```

---

`readAncoraIntoSQLite`    *Read Ancora legacy CNE format*

---

**Description**

Read Ancora legacy CNE format into a SQLite database.

**Usage**

```
readAncoraIntoSQLite(cneFns, dbName, overwrite=FALSE)
```

**Arguments**

|                        |                                                             |
|------------------------|-------------------------------------------------------------|
| <code>cneFns</code>    | character(n): filenames of Ancora CNE files.                |
| <code>dbName</code>    | character(1): filename of SQLite database.                  |
| <code>overwrite</code> | boolean(1): whether or not to overwrite the existing table. |

**Details**

The Ancora legacy CNE file has the filename in the format of "cne2wBf\_AstMex102\_danRer10\_48\_50". The first six columns are the coordinates of pairs of CNEs. The start coordinate system is 0-based and is converted into 1-based when it is imported into the SQLite database.

**Value**

A character vector of table names.

**Note**

This function is mainly for internal use in Lenhard group.

**Author(s)**

Ge Tan

**See Also**

[readAncora](#)

**Examples**

```
ancoraCNEsFns <- file.path(system.file("extdata", package="CNEr"),
                             c("cne2wBf_cypCar1_danRer10_100_100",
                               "cne2wBf_cteIde1_danRer10_100_100",
                               "cne2wBf_AstMex102_danRer10_48_50"))
dbName <- tempfile()
readAncoraIntoSQLite(ancoraCNEsFns, dbName, overwrite=FALSE)
```

---

|         |                        |
|---------|------------------------|
| readAxt | <i>Read 'Axt' file</i> |
|---------|------------------------|

---

## Description

This function reads the 'Axt' files into an [Axt](#) object.

## Usage

```
readAxt(axtFiles, tAssemblyFn=NULL, qAssemblyFn=NULL)
```

## Arguments

**axtFiles**                character(n): filenames of the 'Axt' files to read.  
**tAssemblyFn, qAssemblyFn**        character(1): filename of the 'twoBit' or 'fasta' file for the target and query genome.

## Details

This function reads the 'Axt' files of two assemblies. It can be a single big 'Axt' file or several small 'Axt' files. Contrary to the start coordinate in 'Axt' file, the start coordinate in Axt object is 1-based.

When 'tAssemblyFn' and 'qAssemblyFn' are not NULL, the corresponding Seqinfo will be added into the returned Axt object.

## Value

A object [Axt](#) is returned.

## Author(s)

Ge Tan

## See Also

[Axt](#)

## Examples

```
axtFile <- file.path(system.file("extdata", package="CNEr"),
                      "hg38.danRer10.net.axt")
tAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Hsapiens.UCSC.hg38"),
                          "single_sequences.2bit")
qAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Drerio.UCSC.danRer10"),
                          "single_sequences.2bit")
axt <- readAxt(axtFile, tAssemblyFn, qAssemblyFn)
```



---

|         |                      |
|---------|----------------------|
| readBed | <i>Read bed file</i> |
|---------|----------------------|

---

## Description

Read the coordinates information from a bed file.

## Usage

```
readBed(bedFile, assemblyFn=NULL)
```

## Arguments

|            |                                                                   |
|------------|-------------------------------------------------------------------|
| bedFile    | character(1): filename of the 'bed' file to read.                 |
| assemblyFn | character(1): filename of the twoBit or fasta file of the genome. |

## Details

This function is designed to read the bed file as 'chrom', 'chromStart', 'chromEnd'. The strand information is also stored where available.

In the bed file, the 'chromStart' is on the 0-based coordinate system while 'chromEnd' is on the 1-based coordinate system. For example, the first 100 bases of a chromosome are defined as 'chromStart=0', 'chromEnd=100', and span the bases numbered 0-99. When it is read into GRanges, both the 'chromStart' and 'chromEnd' are on 1-based coordinate, *i.e.*, 'chromStart=1' and 'chromEnd=100'.

When 'assemblyFn' is not NULL, the corresponding Seqinfo will be added into the returned GRanges.

## Value

A GRanges object is returned. When no strand information is available in the bed file, all the ranges are assumed to be on the positive strand.

## Author(s)

Ge Tan

## References

<https://genome.ucsc.edu/FAQ/FAQformat.html#format1>

## See Also

[import.bed](#)

**Examples**

```
bedFn <- file.path(system.file("extdata", package="CNEr"),
  "filter_regions.hg38.bed")
assemblyFn <- file.path(system.file("extdata",
  package="BSgenome.Hsapiens.UCSC.hg38"),
  "single_sequences.2bit")
bed <- readBed(bedFn, assemblyFn=assemblyFn)
```

---

readCNERangesFromSQLite

*readCNERangesFromSQLite function*


---

**Description**

Query the SQLite database based on chromosome, coordinates and some other criteria. Primarily not intended to be used directly. For the CNE density plot, fetchCNEDensity function should be used.

**Usage**

```
readCNERangesFromSQLite(dbName, tableName, chr=NULL, start=NULL, end=NULL,
  whichAssembly=c("first", "second"), minLength=NULL,
  tAssemblyFn=NULL, qAssemblyFn=NULL)
```

**Arguments**

|                          |                                                                                                             |
|--------------------------|-------------------------------------------------------------------------------------------------------------|
| dbName                   | A object of character, the path of the local SQLite database.                                               |
| tableName                | A object of character, the name of table for this CNE data table.                                           |
| chr                      | character(n): the chromosomes to query. When it's NULL, all CNEs will be returned.                          |
| start, end               | integer(n): the start and end coordinates to fetch the CNEs.                                                |
| whichAssembly            | character(1): The coordinates to fetch CNEs are based on 'first' genome or 'last' genome.                   |
| minLength                | integer(1): the minimal length for selected CNEs. The pair of CNEs must be both longer than this minLength. |
| tAssemblyFn, qAssemblyFn | character(1): filename of the 'twoBit' or 'fasta' file for the target and query genome.                     |

**Value**

An object of GRangePairs is returned.

**Author(s)**

Ge Tan

**Examples**

```

dbName <- file.path(system.file("extdata", package="CNEr"),
                     "danRer10CNE.sqlite")
tableName <- "danRer10_hg38_45_50"

qAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Hsapiens.UCSC.hg38"),
                         "single_sequences.2bit")
tAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Drerio.UCSC.danRer10"),
                         "single_sequences.2bit")

## single chr, start, end
chr <- "chr6"
start <- 24000000L
end <- 27000000L
minLength <- 50L
fetchedCNERanges <- readCNERangesFromSQLite(dbName, tableName, chr,
                                             start, end,
                                             whichAssembly="first",
                                             minLength=minLength,
                                             tAssemblyFn=tAssemblyFn,
                                             qAssemblyFn=qAssemblyFn)

## multiple chr, start, end
chr=c("chr1", "chr3")
start=c(90730248, 137523122)
end=c(90730300, 137523190)
fetchedCNERanges <- readCNERangesFromSQLite(dbName, tableName, chr,
                                             start, end,
                                             whichAssembly="second",
                                             minLength=minLength)

## chr, NULL, NULL
fetchedCNERanges <- readCNERangesFromSQLite(dbName, tableName, chr,
                                             start=NULL, end=NULL,
                                             whichAssembly="second",
                                             minLength=minLength)

```

reverseCigar

*reverseCigar function***Description**

This function reverses the cigar string, i.e., 20M15I10D will be reversed to 10D15I20M.

**Usage**

```
reverseCigar(cigar, ops=CIGAR_OPS)
```

**Arguments**

|       |                                                                                     |
|-------|-------------------------------------------------------------------------------------|
| cigar | A character vector of cigar strings.                                                |
| ops   | A character vector of the extended CIGAR operations. By default, CIGAR_OPS is used. |

**Value**

A character vector contains the reversed cigar strings.

**Author(s)**

Ge Tan

**See Also**

[cigar-utils](#)

**Examples**

```
cigar = c("20M15I10D", "10D15I20M")
reverseCigar(cigar)
```

---

saveCNEToSQLite-methods

*Save CNE to SQLite*

---

**Description**

This function saves the CNE results into a local SQLite database.

**Usage**

```
saveCNEToSQLite(x, dbName, tableName=NULL, overwrite=FALSE)
```

**Arguments**

|           |                                                                                                                                                                                                             |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x         | An object of CNE, with CNEFinal computed or a GRangePairs object.                                                                                                                                           |
| dbName    | character(1): the filename of the local SQLite database.                                                                                                                                                    |
| tableName | character(1): the name of table for this CNE data table. When it is NULL, the table name will be inferred from the assembly filenames and scanning window/identity, in the format of "danRer10_hg38_49_50". |
| overwrite | boolean(1): whether or not to overwrite the existing table.                                                                                                                                                 |

**Details**

before loading into an SQLite database, a bin indexing system is used to index the CNE range, which provides faster SQL query.

**Author(s)**

Ge Tan

**Examples**

```

dbName <- tempfile()
data(cneFinalListDanRer10Hg38)
tableNames <- paste("danRer10", "hg38", names(cneFinalListDanRer10Hg38),
                    sep="_")
for(i in 1:length(cneFinalListDanRer10Hg38)){
  saveCNEToSQLite(cneFinalListDanRer10Hg38[[i]], dbName, tableNames[i],
                  overwrite=TRUE)
}

```

scoringMatrix

*scoringMatrix***Description**

Generates the scoring matrix for *lastz* aligner.

**Usage**

```
scoringMatrix(distance = c("far", "medium", "near"))
```

**Arguments**

|          |                                                                                                                                                                                                                                                                                                                            |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| distance | It can be "far", "medium" or "close". It defines the scoring matrix used in <i>lastz</i> aligner. Generally, if two species are close to each other, for example human and chimp, "close" should be used. If two species have a divergence time of 100 MYA, "far" should be used. In other cases, "medium" should be used. |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

**Value**

A matrix of the scoring matrix is returned.

**Note**

HOXD70 is medium. HoxD55 is far. human-chimp.v2 is close.

**Author(s)**

Ge Tan

**References**

[http://genomewiki.ucsc.edu/index.php/Hg38\\_17-way\\_conservation\\_lastz\\_parameters](http://genomewiki.ucsc.edu/index.php/Hg38_17-way_conservation_lastz_parameters)

**See Also**[lastz](#)**Examples**

```
scoringMatrix(distance="far")
```

subAxt-methods

*Subset an Axt object***Description**

A ‘subAxt’ method for extracting a set of alignments from an Axt object.

**Usage**

```
subAxt(x, chr, start, end, select=c("target", "query"), qSize=NULL)
```

**Arguments**

|            |                                                                                                                                                                                                                           |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| x          | An object of Axt.                                                                                                                                                                                                         |
| chr        | An object of character containing the names of the sequences in ‘x’ where to get the alignments from, or a GRanges object where ‘start’ and ‘end’ are missing. In the case of GRanges, the strand information is ignored. |
| start, end | An object of integer() or missing. These ranges should be based on the positive strand. When select is "query", the reverse complement alignments which lay inside this range will also be selected.                      |
| select     | When select is ‘target’, the subset criteria are applied on target alignments in Axt. When select is ‘query’, the subset criteria are applied on query alignments in Axt.                                                 |
| qSize      | integer(n): When select is ‘query’, ‘qSize’ must exist in ‘x’ or can be provided as a vector of chromosome lengths.                                                                                                       |

**Details**

Usually when we want to subset some axts from a Axt object, we care about all the axts within a certain range. The axts can come from the axt file with chr as reference (*i.e.*, target sequence), or the axt file with chr as query sequence. When the chr is query sequence, it can be on the negative strand. Hence, the size of chromosome is necessary to convert the search range to a range on negative strand coordinate.

When one Axt alignment partially overlaps the range, the whole Axt alignment will be extracted.

**Value**

An extracted Axt object is returned.

**Author(s)**

Ge Tan

**See Also**[psubAxt](#)**Examples**

```
library(GenomicRanges)
library(rtracklayer)

## Prepare the axt object
tAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Hsapiens.UCSC.hg38"),
                         "single_sequences.2bit")
qAssemblyFn <- file.path(system.file("extdata",
                                     package="BSgenome.Drerio.UCSC.danRer10"),
                         "single_sequences.2bit")
axtFilesHg38DanRer10 <- file.path(system.file("extdata", package="CNER"),
                                  "hg38.danRer10.net.axt")
axtHg38DanRer10 <- readAxt(axtFilesHg38DanRer10, tAssemblyFn, qAssemblyFn)

## "character", "integer", "integer" on "target" sequence
subAxt(axtHg38DanRer10, chr="chr1", start=148165963L, end=222131835L,
       select="target")

## "GRanges" on "target" sequence
searchGRanges <- GRanges(seqnames="chr1",
                         ranges=IRanges(start=148165963L,
                                       end=222131835L),
                         strand="+")
subAxt(axtHg38DanRer10, searchGRanges, select="target")

## multiple "character", "integer", "integer" on "target" sequence
subAxt(axtHg38DanRer10, chr=c("chr1", "chr13"),
       start=c(148165963L, 94750629L),
       end=c(222131835L, 94966991L), select="target")

## "character" only on "target" sequence
subAxt(axtHg38DanRer10, chr="chr1", select="target")

## GRanges on "query" sequence
searchGRanges <- GRanges(seqnames="chr6",
                         ranges=IRanges(start=25825774,
                                       end=26745499),
                         strand="+")
subAxt(axtHg38DanRer10, searchGRanges, select="query")
```

---

summary

*Utility functions related to Axt alignment*


---

**Description**

A collection of different functions used to deal with Axt object.

**Usage**

```
summary(object, ...) ## mismatch number and proportion
```

**Arguments**

|        |                     |
|--------|---------------------|
| object | An Axt object       |
| ...    | Currently not used. |

**Value**

A table object with the counts of mismatches, insertions, deletions and the matches of each base.

**Author(s)**

Ge Tan

**Examples**

```
axtFilesHg38DanRer10 <- file.path(system.file("extdata", package="CNEr"),
                                   "hg38.danRer10.net.axt")
axtHg38DanRer10 <- readAxt(axtFilesHg38DanRer10)
summary(axtHg38DanRer10)
```

---

syntenicDotplot-methods

*Syntenic dotplot*


---

**Description**

Syntenic dotplot for Axt alignment object or GRangePairs.

**Usage**

```
syntenicDotplot(x, firstSeqlengths=NULL, secondSeqlengths=NULL,
               firstChrs=NULL, secondChrs=NULL,
               col=c("blue", "red"), type=c("line", "dot"))
```



**Arguments**

|                                                |                                                                                                                            |
|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| <code>x</code>                                 | Axt object: the whole genome pairwise alignment of two species under comparison or GRangePairs object.                     |
| <code>firstSeqlengths, secondSeqlengths</code> | integer(n): seqlengths for both the first (target) and second (query) genomes. When NULL, the seqlengths must exist in x.  |
| <code>firstChrs, secondChrs</code>             | character(n): the chromosomes to compare.                                                                                  |
| <code>col</code>                               | character(2): the colours for positive and negative strands.                                                               |
| <code>type</code>                              | "line" or "dot" plot type: When plotting massive number of ranges, "dot" should be used. Otherwise, "line" should be used. |

**Details**

This syntenic dotplot is a type of scatter plot for Axt object, and line plot for GRangePairs object. In the case of possibly massive number of Axt alignments, the line plots will make it invisible at a large genome scale.

Each axis represents concatenated selected chromosomes laid end-to-end, and each dot in the scatter-plot represents a putative homologous match between the two genomes. These dotplots are used for whole genome comparisons within the same genome or across two genomes from different taxa in order to identify synteny.

**Value**

A ggplot object.

**Note**

For highly fragmented assemblies, the synteny is invisible on the dotplot.

**Author(s)**

Ge Tan

**Examples**

```
library(GenomeInfoDb)
library(BSgenome.Ggallus.UCSC.galGal3)
library(BSgenome.Hsapiens.UCSC.hg19)
## dotplot for Axt object
fn <- file.path(system.file("extdata", package="CNEr"),
                 "chr4.hg19.galGal3.net.axt.gz")
axt <- readAxt(fn)
firstSeqlengths <- seqlengths(BSgenome.Hsapiens.UCSC.hg19)
secondSeqlengths <- seqlengths(BSgenome.Ggallus.UCSC.galGal3)
firstChrs <- c("chr4")
secondChrs <- c("chr4")
syntenicDotplot(axt, firstSeqlengths, secondSeqlengths,
                firstChrs=firstChrs, secondChrs=secondChrs,
```

```

        type="dot")

## dotplot for GRangePairs object
data(grangesPairsForDotplot)
syntenicDotplot(grangesPairsForDotplot, type="line")

```

---

writeAxt

writeAxt *function*


---

### Description

Write an axt object into a file.

### Usage

```
writeAxt(axt, con)
```

### Arguments

|     |                                                            |
|-----|------------------------------------------------------------|
| axt | An Axt object to write.                                    |
| con | A <a href="#">connection</a> object or a character string. |

### Author(s)

Ge Tan

### See Also

[readAxt](#)

### Examples

```

axtFile <- file.path(system.file("extdata", package="CNEr"),
                      "hg38.danRer10.net.axt")

axt <- readAxt(axtFile)
writeAxt(axt, con=tempfile())

```

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