Package ‘CNEr’

March 28, 2017

Version 1.10.2
Date 2016-10-25
Title CNE Detection and Visualization
Description Large-scale identification and advanced visualization of sets of conserved noncoding elements.
Author Ge Tan <ge.tan09@imperial.ac.uk>
Maintainer Ge Tan <ge.tan09@imperial.ac.uk>
Imports Biostrings (>= 2.33.4), RSQLite (>= 0.11.4), GenomeInfoDb (>= 1.1.3), GenomicRanges (>= 1.23.16), rtracklayer (>= 1.25.5), XVector (>= 0.5.4), GenomicAlignments (>= 1.1.9), methods, S4Vectors (>= 0.9.25), IRanges (>= 2.5.27), readr (>= 0.2.2), BiocGenerics, tools, parallel, reshape2 (>= 1.4.1), ggplot2 (>= 2.1.0), poweRlaw (>= 0.60.3), annotate (>= 1.50.0), GO.db (>= 3.3.0), R.utils (>= 2.3.0), KEGGREST (>= 1.14.0)
Depends R (>= 3.2.2)
Suggests Gviz (>= 1.7.4), BiocStyle, knitr, rmarkdown, testthat, BSgenome.Drerio.UCSC.danRer10, BSgenome.Hsapiens.UCSC.hg38, TxDb.Drerio.UCSC.danRer10.refGene, BSgenome.Hsapiens.UCSC.hg19, BSgenome.Ggallus.UCSC.galGal3
LinkingTo S4Vectors, IRanges, XVector
VignetteBuilder knitr
License GPL-2 | file LICENSE
License_restricts_use yes
URL https://github.com/ge11232002/CNEr
BugReports https://github.com/ge11232002/CNEr/issues
Type Package
biocViews GeneRegulation, Visualization, DataImport
NeedsCompilation yes
LazyData no
R topics documented:

axisTrack .......................................................... 3
Axt-class ............................................................ 3
axtChain ............................................................ 5
axtInfo ............................................................... 6
binning-utils ......................................................... 7
blatCNE .............................................................. 8
ceScan-methods ...................................................... 9
chainMergeSort ....................................................... 10
chainNetSyntenic .................................................... 12
chainPreNet .......................................................... 13
CNE-class ............................................................. 15
CNEDanRer10Hg38 .................................................. 17
CNEDensity-methods ................................................ 17
cneFinalListDanRer10Hg38 ........................................ 18
cneMerge-methods ................................................... 19
fetchChromSizes ..................................................... 20
fixCoordinates ......................................................... 21
GRangePairs-class .................................................. 22
grangesPairsForDotplot ............................................. 24
lastal ................................................................. 25
lastz ................................................................. 26
lavToPsl .............................................................. 27
makeAncoraFiles ..................................................... 28
makeCNEDensity ...................................................... 29
makeGRBs ........................................................... 30
matchDistribution .................................................... 31
N50 ................................................................. 32
netToAxt ............................................................. 33
orgKEGGIds2EntrezIDs ............................................. 34
plotCNEDistribution ................................................ 35
plotCNEDensity ....................................................... 36
psubAxt ............................................................. 37
queryCNEData ......................................................... 38
read.rmMask.GRanges .............................................. 39
read.rmskFasta ....................................................... 39
readAncora ........................................................... 40
readAncoraIntoSQLite ............................................. 41
readAxt ............................................................. 42
readBed ............................................................. 43
readCNERangesFromSQLite ........................................ 44
reverseCigar ........................................................ 45
saveCNEDatabase-methods ......................................... 46
scoringMatrix ......................................................... 47
subAxt-methods ....................................................... 48
summary ............................................................ 49
syntenicDotplot-methods .......................................... 50
writeAxt ............................................................. 51

Index 53
Example data for plotting annotation.

**Description**

Five annotation tracks for plotting in Gviz.

**Usage**

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

**Details**

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

**Examples**

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

---

Class "Axt"

**Description**

The Axt S4 object to hold a axt file.

**Usage**

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

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

Arguments

- `targetRanges`: Object of class "GRanges": The ranges of net alignments on reference genome.
- `targetSeqs`: Object of class "DNAStringSet": The alignment sequences of reference genome.
- `queryRanges`: Object of class "GRanges": The ranges of net alignments on query genome.
- `querySeqs`: Object of class "DNAStringSet": The alignment sequences of query genome.
- `score`: Object of class "integer": The alignment score.
- `symCount`: Object of class "integer": The alignment length.
- `names`: character(): the names of axt alignments.
- `x`: 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`

Examples

```r
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("ATTTATGTC", "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("ATTTAAGTG", "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)

---

### 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", psls, ignore.case=TRUE),
    assemblyTarget, assemblyQuery,
    distance=c("far", "medium", "near"),
    removePsl=TRUE, binary="axtChain")`

### Arguments

- **psls** character(n): file names of input psl files.
- **chains** character(n): file names of output chain files. By default, in the same folder of input lav files with same names.
- **assemblyTarget** character(1): the file name of target assembly twoBit file.
- **assemblyQuery** character(1): the file name of query assembly twoBit file.
distance It can be "far", "medium" or "close". It decides the score matrix used in lastz aligner. See '?scoringMatrix' for more details.
removePsl boolean: When TRUE, the input psl 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", ext="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

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

bining-utils

UCSC bin indexing system utility functions

Description

Utility functions for UCSC bin indexing system manipulation

Usage

```r
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
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 blat 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

```r
## 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)
```

---

**Description**

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

**Usage**

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

**Arguments**

- `x` CNE object, or Axt object, or character(n) object of Axt filenames.
- `tFilter, qFilter` GRanges object or NULL: regions to filter out for target and query assembly.
- `tSizes, qSizes` 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'.
- `window` integer(n): the window size of scanning CNEs. By default, it is 50L.
- `identity` 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 GRanges or CNE object is returned. Each element of the list corresponds to one user-specified threshold for identifying CNEs.
Author(s)
Ge Tan

Examples

```r
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 <- fetchChromSizes("hg38")
qSizesDanRer10 <- fetchChromSizes("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)
```

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.
chainMergeSort

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 chains files.
assemblyTarget character(1): the file name of target assembly twoBit file.
assemblyQuery character(1): the file name of query assembly twoBit file.
allChain character(1): file names of merged allChain file.
removeChains boolean: When TRUE, the input chains files will be removed after the conver-
sion.
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=TRUE, binary="chainMergeSort")
Description

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

Usage

```r
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(l): file names of input `allPreChain` file.
- `assemblyTarget`: character(l): the file name of target assembly `twoBit` file.
- `assemblyQuery`: character(l): the file name of query assembly `twoBit` file.
- `binaryChainNet`: character(l): the name/filename of the binary `chainNet` to call.
- `binaryNetSyntenic`: character(l): 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(l): the file names of generated `net` file.

Author(s)

Ge Tan
chainPreNet

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

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

```r
## 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)
```
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:

```r
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:

```r
## 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)
```

Arguments

- `assembly1Fn`: Object of class "character": The twoBit filenames of assembly1, assembly2
- `assembly2Fn`: Object of class "character": The twoBit filenames of assembly1, assembly2
- `axt12Fn`: Object of class "character": The Axt filenames of assembly1 to assembly2, assembly2 to assembly1
- `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.
CNE-class

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 <- GRangesP

CNE21 <- GRangesP

cne <- CNE
"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)

**CNEDanRer10Hg38 and CNEDanRer10Hg38 dataset**

**Description**
These two datasets are the direct output from ceScan.

**Usage**
data(CNEHg38DanRer10)

**Examples**
data(CNEHg38DanRer10)

**CNEDensity-methods**

**CNEDensity function**

**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)
Description

Removes the CNEs which overlap on both genomes.

Usage

cneMerge(cne12, cne21)

Arguments

cne12  A object of CNE or GRanges.
cne21  A object of GRanges object. When cne12 is a CNE object, cne21 can be missing.

Value

A GRanges 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 <- GRangesPairs(firstGRange[1:3], lastGRange[1:3])
cne21 <- GRangesPairs(lastGRange[4:5], firstGRange[4:5])
## GRanges, GRangesPairs

## 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,
fetchChromSizes

CNE12=cne12, CNE21=cne21, aligner="blat")
cneMerge(cne)

fetchChromSizes fetchChromSizes function.

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 utilises mysql queries 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")
**Fix the coordinates in Axt object**

**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**

```r
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**

```r
taxtFnDanRer10Hg38 <- 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")
taxtDanRer10Hg38 <- readAxt(axtFnDanRer10Hg38, tAssemblyFn=tAssemblyFn, qAssemblyFn=qAssemblyFn)
## Fix the coordinates
fixCoordinates(axtDanRer10Hg38)

## Restore it
fixCoordinates(fixCoordinates(axtDanRer10Hg38))
```
The GRangePairs class is a container for a pair of GRanges objects that have the same lengths.

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.

GRangePairs constructor:

\[
\text{GRangePairs}(\text{first} = \text{GRanges}(), \text{second} = \text{GRanges}(), \ldots, \text{names} = \text{NULL}, \text{hits} = \text{NULL}): \text{GRangePairs} \text{ constructor.}
\]

Accessors

In the code snippets below, \(x\) is a GRangePairs object.

- \(\text{length}(x)\): Return the number of granges pairs in \(x\).
- \(\text{names}(x), \text{names}(x) \leftarrow \text{value}\): Get or set the names on \(x\).
- \(\text{first}(x), \text{last}(x), \text{second}(x)\): Get the ‘first’ or ‘last’/‘second’ GRanges for each grange pair in \(x\). The result is a GRanges object of the same length as \(x\).
- \(\text{first}(x) \leftarrow, \text{second}(x) \leftarrow\): Set the ‘first’ or ‘second’ GRanges for each grange pair in \(x\). The result is a GRanges object of the same length as \(x\).
- \(\text{seqnames}(x)\): Get the seqname of first GRanges and last GRanges and return in a DataFrame object.
- \(\text{strand}(x)\): Get the strand for each grange pair in \(x\).
- \(\text{seqinfo}(x)\): 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.

\(\text{unlist}(x, \text{use.names} = \text{TRUE})\): Return the GRangePairs object conceptually defined by \(c(x[[1]], x[[2]], \ldots, x[[\text{length}(x)]]\). \text{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.

\[
grglist(x, \text{use.mcols}=\text{FALSE}):\]
Return a GRangesList object of length \( \text{length}(x) \) 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 \( \text{use.mcols} \) is \text{TRUE} and \( x \) has metadata columns on it (accessible with \( \text{mcols}(x) \)), they're propagated to the returned object.

\[
as(x, \text{"GRangesList"}): \text{Alternate ways of doing grglist}(x, \text{use.mcols=TRUE}).\]
\[
as(x, \text{"GRanges"}): \text{Equivalent of } \text{unlist}(x, \text{use.names=TRUE}).\]

Other methods

In the code snippets below, \( x \) is a GRangesList object.

\[
\text{swap}(x): \text{Swap the first, last GRanges.}\]
\[
\text{unique}(x): \text{Get the unique GRangePairs.}\]
\[
\text{show}(x): \text{By default, the show method displays 5 head and 5 tail elements. This can be changed by setting the global options showHeadLines and showTailLines. If the object length is less than (or equal to) the sum of these 2 options plus 1, then the full object is displayed.}\]

Author(s)

Ge Tan

See Also

Axt

Examples

```r
## 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(rangesPairs1)
names(rangesPairs2) <- namesGRangePairs

first(rangesPairs1)
```
```r
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**

**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)
Description

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

Usage

```r
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 output `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/](http://last.cbrc.jp/)

See Also

- `lastz`
Examples

```r
## 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

```r
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 `twoBit` file.
- `assemblyQuery`: character(1): the file name of query assembly `twoBit` file.
- `outputDir`: character(1): the folder to put the generated `lav` 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 `lastz` aligner. See '?scoringMatrix' for more details.
- `binary`: character(1): the name/filename of the binary `lastz` 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 `lastz` 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

```r
## 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"
assembleQuery <- "/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

### 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

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

### Arguments

- `lavs` character(n): file names of input lav files.
- `psls` character(n): file names of output psl files. By default, in the same folder of input lav files with same names.
- `removeLav` boolean: When TRUE, the input lav files will be removed after the conversion.
- `binary` character(1): the name/filename of the binary lavToPsl 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

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.
makeCNEDensity

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")

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

Description

Make 'Bed', 'bedGraph' and '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", place="CNEr"),
  "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

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

x GRangesList object of a set of CNEs to use.

winSize integer: the smoothing window size for CNE densities in kb. This value de-
  pends 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.

genes NULL or GRanges object: the protein-coding genes ranges.
matchDistribution

ratio numeric(1): the threshold to control the stringency of the GRBs. Higher value, shorter and fewer GRBs, and vice versa.

background 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.

minCNEs 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

```r
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

*Plot the distribution of matched alignments.*

Description

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

Usage

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

<table>
<thead>
<tr>
<th>netToAxt</th>
<th>netToAxt</th>
</tr>
</thead>
</table>

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

| assemblyTarget | character(1): the file name of target assembly twoBit file. |
| assemblyQuery | character(1): the file name of query assembly twoBit file. |
| removeFiles | boolean: When TRUE, the input net and chain 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.
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

orgKEGGIds2EntrezIDs(organism="Homo sapiens")

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

```r
dbName <- file.path(system.file("extdata", package="CNEr"),
  "danRer10CNE.sqlite")
gAssemblyFn <- 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")
cneGRRangePairs <- readCNERangesFromSQLite(dbName=dbName,
  tableName="danRer10_hg38_45_50",
  tAssemblyFn=tAssemblyFn,
  qAssemblyFn=qAssemblyFn)
plotCNEDistribution(first(cneGRRangePairs))
```

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

```r
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 \(x_{min}\), 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
psubAxt

References


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
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 into a GRanges object.

**Usage**

```r
call.rmMask.GRanges(fn)
```

**Arguments**


**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](http://www.repeatmasker.org/webrepeatmaskerhelp.html)

**Examples**

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

---

**read.rmskFasta**

Read a soft repeat masked fasta

**Description**

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

**Usage**

```r
call.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.
Values

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"),
"rmrk.fa")
read.rmskFasta(fn)

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.
**Description**

Read Ancora legacy CNE format into a SQLite database.

**Usage**

readAncoraIntoSQLite(cneFns, dbName, overwrite = FALSE)

**Arguments**

- **cneFns**: character(n): filenames of Ancora CNE files.
- **dbName**: character(1): filename of SQLite database.
- **overwrite**: 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

```
anciaCNEsFns <- file.path(system.file("extdata", package="CNEr"),
   "cne2wBf_cypCar1_danRer10_100_100",
   "cne2wBf_cteIde1_danRer10_100_100",
   "cne2wBf_AstMex102_danRer10_48_50")

dbName <- tempfile()
readAncoraIntoSQLite(anciaCNEsFns, dbName, overwrite=FALSE)
```

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)
```

### 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](https://genome.ucsc.edu/FAQ/FAQformat.html#format1)
readCNERangesFromSQLite

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 <- 27000000
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

ingest-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
scoringMatrix

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 lastz 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

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

```r
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(seqsnames="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(seqsnames="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)

Description

Syntenic dotplot for Axt alignment object or GRanges object.

Usage

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

Arguments

x  

Axt object: the whole genome pairwise alignment of two species under comparison or GRanges object.

firstSeqlengths, secondSeqlengths

integer(n): seqlengths for both the first (target) and second (query) genomes. When NULL, the seqlengths must exist in x.

firstChrs, secondChrs

character(n): the chromosomes to compare.

col  

character(2): the colours for positive and negative strands.

type  

"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)

## dotplot for Axt object
fn <- file.path(system.file("extdata", package="CNEr"), "chr4.hg19.galGal3.net.axt.gz")
axt <- readAxt(fn)
firstSeqlengths <- seqlengths(fetchChromSizes("hg19"))
secondSeqlengths <- seqlengths(fetchChromSizes("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 function

Description

Write an axt object into a file.

Usage

writeAxt(axt, con)
writeAxt

Arguments

- **axt**: An Axt object to write.
- **con**: A connection object or a character string.

Author(s)

Ge Tan

See Also

readAxt

Examples

```r
axtFile <- file.path(system.file("extdata", package="CNEr"),
                      "hg38.danRer10.net.axt")
axt <- readAxt(axtFile)
writeAxt(axt, con=tempfile())
```
Index

*Topic `textasciitildedekwd1`
  queryCNEData, 38
*Topic `textasciitildedekwd2`
  queryCNEData, 38
*Topic `classes`
  Axt-class, 3
  CNE-class, 15
*Topic `datasets`
  axisTrack, 3
  CNEDanRer10Hg38, 17
  grangesPairsForDotplot, 24
  [], Axt, ANY, ANY-method (Axt-class), 3
axisTrack, 3
Axt, 23, 42
Axt (Axt-class), 3
Axt-class, 3
axtChain, 5, 11
axtInfo, 6
binFromCoordRange (binning-utils), 7
binning-utils, 7
binRangesFromCoordRange (binning-utils), 7
binRestrictionString (binning-utils), 7
blatCNE, 8
c, Axt-method (Axt-class), 3
c, GRangePairs-method
  (GRangePairs-class), 22
ceScan (ceScan-methods), 9
ceScan, Axt-method (ceScan-methods), 9
ceScan, CNE-method (ceScan-methods), 9
cceScan-methods, 9
chainMergeSort, 10, 14
chainNetSyntenic, 12, 34
chainPreNet, 13, 13
class: GRangePairs (GRangePairs-class), 22
CNE (CNE-class), 15
CNE-class, 15
CNE12 (CNE-class), 15
CNE12, CNE-method (CNE-class), 15
CNE21 (CNE-class), 15
CNE21, CNE-method (CNE-class), 15
CNEDanRer10Hg38, 17
CNEDensity (CNEDensity-methods), 17
CNEDensity, ANY, character, character, missing, missing-method
  (CNEDensity-methods), 17
CNEDensity, ANY, missing, character, character, character-method
  (CNEDensity-methods), 17
CNEDensity-methods, 17
CNEFinal (CNE-class), 15
CNEFinal, CNE-method (CNE-class), 15
cNEFinalListDanRer10Hg38, 18
CNEHg38DanRer10 (CNEDanRer10Hg38), 17
cneMerge (cneMerge-methods), 19
cneMerge, CNE, missing-method
  (cneMerge-methods), 19
cneMerge, GRangePairs, GRangePairs-method
  (cneMerge-methods), 19
cneMerge-methods, 19
CNEmerged (CNE-class), 15
CNEmerged, CNE-method (CNE-class), 15
coerce, GRangePairs, GRanges-method
  (GRanges-methods), 22
coerce, GRangePairs, GRangesList-method
  (GRanges-methods), 22
connection, 52
cpgIslands (axisTrack), 3
fetchChromSizes, 20
first, GRangePairs-method
  (GRangePairs-methods), 22
fixCoordinates, 4, 21
fixCoordinates, Axt-method
  (fixCoordinates), 21
GRangePairs, 22
GRangePairs (GRangePairs-class), 22
GRangePairs-class, 22
GRanges, 22
GRangesList, 23
grangesPairsForDotplot, 24
grglist, GRangePairs-method
  (GRangePairs-methods), 22
import.bed, 44
INDEX

last (GRangePairs-class), 22

subAxt, 4
subAxt (subAxt-methods), 48
subAxt, Axt, character, integer, integer-method
(subAxt-methods), 48
subAxt, Axt, character, missing, missing-method
(subAxt-methods), 48
subAxt, Axt, character, numeric, numeric-method
(subAxt-methods), 48
subAxt, Axt, GRanges, missing, missing-method
(subAxt-methods), 48
subAxt-methods, 48

summary, 49
summary, Axt-method (summary), 49

swap (GRangePairs-class), 22
swap, GRangePairs-method

(N50), 32
N50 (N98), 32
netToAxt, 33

orgKEGGIds2EntrezIDs, 34

plotCNEDistribution, 35

plotCNEWidth, 35

psubAxt, 37, 37, 48

queryCNEData, 38

queryRanges (Axt-class), 3
queryRanges, Axt-method (Axt-class), 3
querySeqs (Axt-class), 3
querySeqs, Axt-method (Axt-class), 3

read.rmMask.GRanges, 39, 40
read.rmskFasta, 39
readAncora, 29, 30, 40, 41
readAncoraIntoSQLite, 41
readAxt, 4, 7, 42, 52
readBed, 43
readCNERangesFromSQLite, 44
refGenes (axisTrack), 3
reverseCigar, 45

saveCNEToSQLite
(saveCNEToSQLite-methods), 46
saveCNEToSQLite-methods, 46

score, Axt-method (Axt-class), 3

scoringMatrix, 47

second, GRangePairs-method
(GRangePairs-class), 22

seqinfo, GRangePairs-method
(GRangePairs-class), 22

seqnames, GRangePairs-method
(GRangePairs-class), 22

strand, GRangePairs-method
(GRangePairs-class), 22

subAxt, 4
subAxt (subAxt-methods), 48
subAxt, Axt, character, integer, integer-method
(subAxt-methods), 48
subAxt, Axt, character, missing, missing-method
(subAxt-methods), 48
subAxt, Axt, character, numeric, numeric-method
(subAxt-methods), 48
subAxt, Axt, GRanges, missing, missing-method
(subAxt-methods), 48
subAxt-methods, 48

summary, 49
summary, Axt-method (summary), 49

swap (GRangePairs-class), 22
swap, GRangePairs-method

(N50), 32
N50 (N98), 32
netToAxt, 33

orgKEGGIds2EntrezIDs, 34

plotCNEDistribution, 35

plotCNEWidth, 35

psubAxt, 37, 37, 48

queryCNEData, 38

queryRanges (Axt-class), 3
queryRanges, Axt-method (Axt-class), 3
querySeqs (Axt-class), 3
querySeqs, Axt-method (Axt-class), 3

read.rmMask.GRanges, 39, 40
read.rmskFasta, 39
readAncora, 29, 30, 40, 41
readAncoraIntoSQLite, 41
readAxt, 4, 7, 42, 52
readBed, 43
readCNERangesFromSQLite, 44
refGenes (axisTrack), 3
reverseCigar, 45

saveCNEToSQLite
(saveCNEToSQLite-methods), 46
saveCNEToSQLite-methods, 46

score, Axt-method (Axt-class), 3

scoringMatrix, 47

second, GRangePairs-method
(GRangePairs-class), 22

seqinfo, GRangePairs-method
(GRangePairs-class), 22

seqnames, GRangePairs-method
(GRangePairs-class), 22

strand, GRangePairs-method
(GRangePairs-class), 22