

Package ‘ModCon’

January 10, 2025

Type Package

Title Modifying splice site usage by changing the mRNP code, while maintaining the genetic code

Version 1.14.0

Description Collection of functions to calculate a nucleotide sequence surrounding for splice donors sites to either activate or repress donor usage. The proposed alternative nucleotide sequence encodes the same amino acid and could be applied e.g. in reporter systems to silence or activate cryptic splice donor sites.

License GPL-3 + file LICENSE

Encoding UTF-8

LazyData true

VignetteBuilder knitr

Depends data.table, parallel, utils, stats, R (>= 4.1)

Suggests testthat, knitr, rmarkdown, dplyr, shinycssloaders, shiny, shinyFiles, shinydashboard, shinyjs

SystemRequirements Perl

biocViews FunctionalGenomics, AlternativeSplicing

URL <https://github.com/caghtaagtat/ModCon>

git_url <https://git.bioconductor.org/packages/ModCon>

git_branch RELEASE_3_20

git_last_commit 05e5b2f

git_last_commit_date 2024-10-29

Repository Bioconductor 3.20

Date/Publication 2025-01-09

Author Johannes Ptok [aut, cre] (<<https://orcid.org/0000-0002-0322-5649>>)

Maintainer Johannes Ptok <Johannes.Ptok@posteo.de>

Contents

calculateHZEIint	2
calculateMaxEntScanScore	3
cds	3
changeSequenceHZEI	4

Codons	5
createCodonMatrix	6
createFilialSequencePopulation	6
decreaseGTsiteStrength	7
degradeSAs	8
degradeSDs	9
generateRandomCodonsPerAA	9
getOverlappingVectorsFromVector	10
hbg	11
hex	11
increaseGTsiteStrength	12
ModCon	13
mutatePopulation	15
recombineTwoSequences	15
selectBestAndMean	16
selectMatingIndividuals	17
slidingWindowHZEImanipulation	18
startModConApp	19
Index	20

calculateHZEIint	<i>Calculate HZEI integral of nucleotide sequence</i>
------------------	---

Description

This function calculates the HZEI integral of a nucleotide sequence.

Usage

```
calculateHZEIint(ntSequence)
```

Arguments

ntSequence	Character value of nucleotide sequence whose HZEI integral will be calculated. It should be at least 11 nt long and only contain bases 'A', 'G', 'C', 'T'.
------------	--

Value

Integer value stating the HZEI integral of the given sequence ntSequence

Examples

```
## Example to increase HZEI integral for a given coding sequence
x <- calculateHZEIint('ATACCAGCCAGCTATTACATTT')
```

`calculateMaxEntScanScore`*Calculate MaxEntScan score of a splice site sequence*

Description

This function calculates the MaxEntScan score of either splice donor (SD) or acceptor sequences (SA).

Usage

```
calculateMaxEntScanScore(seqVector, ssType)
```

Arguments

seqVector	Character value of nucleotide sequence of a splice site sequence. SA sequences should be 23nt long (20 intronic, 3 exonic) and SD sequences should be 9nt long (3 exonic, 6 intronic). Only bases 'A', 'G', 'C', 'T' permitted.
ssType	Numeric value which indicates the type of splice site. Either '3' for an SA or '5' for an SD.

Value

Numeric vector stating the MaxEntScan score per splice site sequence entered with seqVector

Examples

```
calculateMaxEntScanScore('TTCCAAACGAACTTTTGTAGGGA', 3)  
calculateMaxEntScanScore('GAGGTAAGT', 5)
```

`cds`*CDS of firefly luciferase*

Description

Character string of the nucleotide sequence encoding the firefly luciferase.

Usage

```
cds
```

Format

character string

Examples

```
cds
```

changeSequenceHZEI *Adjust HZEI integral of nucleotide sequence*

Description

Adjust the HZEI integral of a nucleotide sequence (min. 24nt long)

Usage

```
changeSequenceHZEI(inSeq, increaseHZEI=TRUE, nGenerations=50, parentSize=300,
startParentSize=1000, bestRate=50, semiLuckyRate=20, luckyRate=5, mutationRate=1e-04,
optiRate=100, sdMaximalHBS=10, acMaximalMaxent=4, nCores=-1)
```

Arguments

inSeq	Character value of nucleotide sequence (min 24nt long, only bases A, G, T or C)
increaseHZEI	Logical value if HZEI integral should be increased or decreased during SD degradation. If TRUE, function aims to increase HZEI integral.
nGenerations	Numeric value setting maximal number of generations
parentSize	Numeric value setting size of parent generations, generated from previous generations
startParentSize	Numeric value setting size of initiated parent generation of sequences
bestRate	Numeric value setting percentage how many of the fittest sequences are used to produce the next generation
semiLuckyRate	Numeric value setting percentage of sequences which are selected for breeding with a probability based on the respective HZEI-score integral
luckyRate	Numeric value setting percentage of sequences which are randomly selected for breeding
mutationRate	Numeric value setting chance of each codon, to mutate randomly within a child sequence
optiRate	Numeric value setting level of HZEI integral optimization
sdMaximalHBS	Numeric value of minimal HBS of SDs which should be tried to be degraded in their intrinsic strength
acMaximalMaxent	Numeric value of minimal MaxEntScan score of SAs which should be tried to be degraded in their intrinsic strength
nCores	Numeric value setting number of cores which should be used for parallel computations. If set to '-1' all available cores are selected.

Value

Character value of a nucleotide sequence encoding the same amino acid sequence as inSeq, but an increased HZEI integral, due to alternative codon selection.

Examples

```
## Load R packages
library('parallel')
library('utils')
library('data.table')

## Set parameters for genetic algorithm
inSeq <- 'ATGGAAGACGCCAAAAACATAAAGAAAGCCCGGCCATTCTATCCGCTGGAAGATGGAACC'

## Increase HZEI integral
res <- changeSequenceHZEI(inSeq)

## Setting additional parameters
res <- changeSequenceHZEI(inSeq, increaseHZEI=TRUE, nGenerations=50, parentSize=300,
startParentSize=1000, bestRate=50, semiLuckyRate=20, luckyRate=5, mutationRate=1e-04,
optiRate=100, sdMaximalHBS=10, acMaximalMaxent=4, nCores=1)

## Access sequence with highest generated HZEI integral
res[[3]]
```

Codons

Table of codons and encoded amino acids

Description

Table of codons and encoded amino acids

Usage

Codons

Format

A data frame with columns:

ndiff Indicator, how many codons encode the same amino acid

AA Amino acid three-lette code

name Amino acid full name

seq Codon sequence

Examples

Codons

createCodonMatrix *Create codon matrix from coding nucleotide sequence*

Description

This function creates a codon matrix with 2 rows and as many columns as codons within the sequence.

Usage

```
createCodonMatrix(cds)
```

Arguments

cds Character value of nucleotide sequence whose HZEI integral will be calculated. It should be at least 3 nt long and only contain bases 'A', 'G', 'C', 'T'. Length must be a multiple of 3.

Value

Character matrix holding the encoded codon sequence in both rows.

Examples

```
## Example to create codon matrix  
createCodonMatrix("ATGAATGATCAAAGCTAGCC")
```

createFilialSequencePopulation
 Generate new sequences by recombination

Description

This function generates new sequences from set of parental sequences through recombination.

Usage

```
createFilialSequencePopulation(sequenceVector, generateNrecombinedSequences)
```

Arguments

sequenceVector Character vector of nucleotide sequences which will be used to create new sequences through recombination.

generateNrecombinedSequences
 Numeric value setting number of recombined sequences which will be generated

Value

Character vector of nucleotide sequences, generated by recombination from the entered sequenceVector, holding as much filial sequences as stated in generateNrecombinedSequences. Modes of recombination are cross-over, insertion and random.

Examples

```
createFilialSequencePopulation(c('AAABBBCCDDDEEEFFF', 'GGGHHIIJJJKKLLL'), 3)
```

```
decreaseGTsiteStrength
```

Remove or degrade intrinsic strength of specific GT site while keeping the HZEI integral neutral.

Description

Degrade or remove specific GT site from a coding sequence by codon selection keeping the HZEI integral near zero.

Usage

```
decreaseGTsiteStrength(cds, sdSeqStartPosition)
```

Arguments

cds Character value of a coding nucleotide sequence which holds the splice site of interest. Sequence length must be dividable by 3 and only contain bases 'A', 'G', 'C', 'T'.

sdSeqStartPosition Numeric value of position of the first nucleotide of the splice donor of interest

Value

Character vector of a nucleotide sequence encoding the same amino acid as the entered cds, but the intrinsic strength of a specific GT site within the CDS is degraded as much as possible.

Examples

```
library(data.table)
cds <- paste0('ATGGAAGACGCCAAAAACATAAAGAAAGGCCCGGCCATTCTATCCGCTGGAAGATGGAACCGCTGGAGAGCAACTGCA',
' TAAGGCTATGAAGAGATACGCCCTGGTTCCTGGAACAATTGCTTTTACAGATGCACATATCGAGGTGGACATCACTTACGCTGAGTACTTCGAAA',
' TGCCGTTTCGGTTGGCAGAAGCTATGAAACGATATGGGCTGAATACAAATCACAGAATCGTCGATGCAGTGAAAACCTCTTCAATTCTTTAT',
' GCCGGTGTGGGCGCGTTATTTATCGGAGTTGCAGTTGCGCCCGCAACGACATTTATAATGAACGTGAATTGCTCAACAGTATGGGCATTTCCG',
' CAGCTACCGTGGTGTTCGTTTCCAAAAAGGGTTGCAAAAAATTTGAACGTGCAAAAAAAGCTCCCAATCATCAAAAAATTATTATCATGG',
' ATTTAAAACGGATTACCAGGGATTTCAAGTCGATGTACACGTTTCGTCACATCTCATCTACCTCCCGGTTTTAATGAATACGATTTTGCCAGA',
' GTCCTTCGATAGGACAAGACAATTGCACTGATCATGAACCTCTGGATCTACTGGTCTGCCTAAAGGTGTCGCTCTGCCTCATAGAAGTCC',
' TCGTGAGATTCTCGCATGCCAGAGATCCTATTTTTGGCAATCAAATCATTCCGGATACTGCGATTTTAAAGTGTGTTCCATTCCATCACGGT',
' TTGGAATGTTTACTACACTCGGATATTTGATATGTGGATTTTCGAGTCGTCTTAATGTATAGATTTGAAGAAGAGCTGTTTCTGAGGAGCCTTCA',
' GGATTACAAGATCAAAGTGCCTGCTGGTGCCAACCCTATTCTCCTTCTCGCCAAAAGCACTCTGATTGACAAATACGATTTATCTAATTTA',
' CACGAAATGCTTCTGGTGGCGCTCCCTCTTAAGGAAGTCGGGAAGCGGTTGCCAAGAGGTTCCATCTGCCAGGTATCAGGCAAGGATATG',
```

```
'GGCTCACTGAGACTACATCAGCTATTCTGATTACACCCGAGGGGATGATAAACCGGGCGCGGTCGGTAAAGTTGTTCCATTTTTGAAGCGAA',
'GGTTGTGGATCTGGATACCGGAAAACGCTGGGCGTTAATCAAAGAGGCCAACTGTGTGTGAGAGGTCCTATGATTATGTCCGGTTATGTAAAC',
'AATCCGGAAGCGACCAACGCCTTGATTGACAAGGATGGATGGCTACATTCTGGAGACATAGCTTACTGGGACGAAGACGAACACTTCTTCATCG',
'TTGACCGCTGAAGTCTCTGATTAAGTACAAAGGCTATCAGGTGGCTCCCGCTGAATTGGAATCCATCTTGCTCCAACACCCCAACATCTTCGA',
'CGCAGGTGTCGCAGGTCTCCCGACGATGACGCCGTGAACCTCCCGCCCGCTTGTGTTTTGGAGCACGGAAGACGATGACGGAAAAAGAG',
'ATCGTGGATTACGTGCGCAGTCAAGTAACAACCGCGAAAAAGTTGCGCGGAGGAGTTGTGTTTGTGGACGAAGTACCGAAAAGTCTTACCGAA',
'AACTCGACGCAAGAAAATCAGAGAGATCCTCATAAAGGCCAAGAAGGGCGGAAGATCGCCGTG')
```

```
sdSeqStartPosition <- 1001
cdsNew <- decreaseGTsiteStrength(cds, sdSeqStartPosition)
print(cdsNew)
```

degradeSAs	<i>Remove or degrade intrinsic strength of splice acceptors while adjusting HZEI integral.</i>
------------	--

Description

Degrade or remove splice acceptor sites of certain intrinsic strength (in MaxEntScan score) from a coding sequence by codon selection while keeping the HZEI integral up.

Usage

```
degradeSAs(fanFunc, maxhbs=10, maxME=4, increaseHZEI=TRUE)
```

Arguments

fanFunc	codon matrix with two rows (see example below)
maxhbs	Numeric threshold which strength of internal donor sites should be degraded (in HBS)
maxME	Numeric threshold which strength of internal acceptor sites should be degraded (in MaxEntScan score)
increaseHZEI	Logical value if HZEI integral should be increased or decreased during SD degradation. If TRUE, function aims to increase HZEI integral.

Value

Character value of a nucleotide sequence encoding the same amino acid as the entered codon matrix fan, but the intrinsic strength of all present splice acceptor (SA) sites is degraded as much as possible, in case they exceed the given threshold maxME. Additionally, splice donor site strengths greater maxhbs are avoided, during SA degradation.

Examples

```
library(data.table)
sdMaximalHBS <- 10
acMaximalMaxent <- 4
increaseHZEI <- TRUE
## Initiating the Codons matrix plus corresponding amino acids
ntSequence <- 'TTTTGTCTTTTCTGTGTGGCAGTGGGATTAGCCTCCTATCGATCTATGCGATA'
## Create Codon Matrix by splitting up the sequence by 3nt
fanFunc <- createCodonMatrix(ntSequence)
degradeSAs(fanFunc, maxhbs=sdMaximalHBS, maxME=acMaximalMaxent, increaseHZEI=increaseHZEI)
```

degradeSDs	<i>Remove or degrade intrinsic strength of splice donors while adjusting HZEI integral.</i>
------------	---

Description

Degrade or remove splice donor sites of certain intrinsic strength (in HBS) from a coding sequence by codon selection.

Usage

```
degradeSDs(fanFunc, maxhbs=10, increaseHZEI=TRUE)
```

Arguments

fanFunc	Codon matrix with two rows (see example below)
maxhbs	Numeric treshold which strength of internal donor sites should be degraded
increaseHZEI	Logical value of HZEI integral should be increased or decreased during SD degradation. If TRUE, function aims to increase HZEI integral.

Value

Character value of a nucleotide sequence encoding the same amino acid as the entered codon matrix fanFunc, but the intrinsic strength of all present splice donors (SD) sites is degraded as much as possible, in case they exceed the given treshold maxhbs.

Examples

```
library(data.table)
## Initiaing the Codons matrix plus corresponding amino acids
ntSequence <- 'TTTTCGATCGGGATTAGCCTCCAGGTAAGTATCTATCGATCTATGCGATAG'
## Create Codon Matrix by splitting up the sequence by 3nt
fanFunc <- createCodonMatrix(ntSequence)
degradeSDs(fanFunc, maxhbs=10, increaseHZEI=TRUE)
```

generateRandomCodonsPerAA	<i>Randomly choose Codon to encode amino acid sequence</i>
---------------------------	--

Description

Encode amino acid sequence by random codon selection

Usage

```
generateRandomCodonsPerAA(aaVector)
```

Arguments

aaVector	Character vector of amino acids in three letter code (e.g. Met)
----------	---

Value

Character value of a nucleotide sequence encoding the same amino acid as the entered by aaVector by random Codon selection.

Examples

```
generateRandomCodonsPerAA(c('Lys', 'Lys'))
```

```
getOverlappingVectorsFromVector  
    Create overlapping subvectors
```

Description

Create overlapping subvectors from large vector

Usage

```
getOverlappingVectorsFromVector(largeVector, subvectorLength, subvectorOverlap )
```

Arguments

largeVector Large character vector to break down into overlapping subvectors

subvectorLength
 Numeric value of length of smaller subvectors

subvectorOverlap
 Numeric value of length of subvector overlap

Value

Creates a list of overlapping subvectors from an input vector largeVector. The length of these overlapping subvectors is stated by subvectorLength and the overlap of the resulting subvectors is stated by subvectorOverlap.

Examples

```
getOverlappingVectorsFromVector(c(1,2,3,4), 2, 1)
```

hbg	<i>Donor sequences and their HBS</i>
-----	--------------------------------------

Description

Donor sequences and their HBS

Usage

hbg

Format

A data frame with columns:

seq 11nt long donor sequence

hbs HBS of the donor sequence

special_seq Shorter version of the donor sequence

Examples

hbg

hex	<i>Hexamers and Z scores</i>
-----	------------------------------

Description

Hexamers and Z scores

Usage

hex

Format

A data frame with columns:

seq Sequence of the hexamer.

value ZEI-score of the hexamer from HEXplorer.

first First codon within the hexamer.

second Second codon within the hexamer.

first_AA First encoded amino acid within the hexamer (three letter code).

second_AA Second encoded amino acid within the hexamer (three letter code).

AA Both encoded amino acid within the hexamer

Examples

hex

increaseGTsiteStrength

Increasing intrinsic strength of specific GT site while keeping the HZEI integral neutral.

Description

Increasing intrinsic strength specific GT site from a coding sequence by codon selection keeping the HZEI integral near zero.

Usage

```
increaseGTsiteStrength(cds, sdSeqStartPosition)
```

Arguments

`cds` Coding nucleotide sequence which holds the splice site of interest
`sdSeqStartPosition` Numeric value of position of the first nucleotide of the splice donor of interest

Value

Character vector of a nucleotide sequence encoding the same amino acid as the entered `cds`, but the intrinsic strength of a specific GT site within the CDS is enhanced as much as possible.

Examples

```
library(data.table)
cds <- paste0('ATGGAAGACGCCAAAAACATAAAGAAAGGCCCGGCCATTCTATCCGCTGGAAGATGGAACCGCTGGAGAGCAACTGCA',
' TAAGGCTATGAAGAGATACGCCCTGGTTCTGGAACAATTGCTTTTACAGATGCACATATCGAGGTGGACATCACTTACGCTGAGTACTTCGAAA',
' TGCCGTTTCGGTTGGCAGAAGCTATGAAACGATATGGGCTGAATACAAATCACAGAATCGTCGATGCAGTGAAAACCTCTTCAATTCTTTAT',
' GCCGGTGTGGGGCGGTTATTTATCGGAGTTGCAGTTGCGCCCGGAACGACATTTAATGAACGTGAATTGCTCAACAGTATGGGCATTTTCG',
' CAGCTACCGTGGTGTTCGTTTCCAAAAAGGGTTGCAAAAAATTTGAACGTGCAAAAAAAGCTCCCAATCATCAAAAAAATTATTATCATGG',
' ATTCTAAAACGGATTACCAGGATTTTCAGTCGATGTACACGTTTCGTCACATCTCATCTACCTCCCGGTTTTAATGAATACGATTTTGTGCCAGA',
' GTCCTTCGATAGGGACAAGACAATTGCACTGATCATGAACCTCTCTGGATCTACTGGTCTGCCTAAAGGTGTCGCTCTGCCTCATAGAAGTCC',
' TGCCTGAGATTCTCGCATGCCAGAGATCCTATTTTGGCAATCAAATCATTCCGGATACTGCGATTTTAAAGTGTGTTCCATTCCATCACGGT',
' TTGGAATGTTTACTACACTCGGATATTTGATATGTGGATTTTCAGTCGTCCTAATGTATAGATTTGAAGAAGAGCTGTTTCTGAGGAGCCTTCA',
' GGATTACAAGATTCAAAAGTGCCTGCTGGTGCCAACCTATTCTCCTTCTCGCCAAAAGCACTCTGATTGACAATACGATTTATCTAATTTA',
' CACGAAATTGCTTTCGGTGGCGTCCCTCTCTAAGGAAGTCGGGAAGCGGTTGCCAAGAGGTTCCATCTGCCAGGTATCAGGCAAGGATATG',
' GGCTCACTGAGACTACATCAGCTATTCTGATTACACCCGAGGGGATGATAAACCGGGCGCGTTCGGTAAAGTTGTTCCATTTTTGAAGCGAA',
' GGTGTGGATCTGGATACCGGAAAAACGCTGGGCGTTAATCAAAGAGGCGAACTGTGTGTGAGAGGTCCTATGATTATGTCCGGTTATGTAAAC',
' AATCCGGAAGCGACCAACGCCTTGATTGACAAGGATGGATGGCTACATTCTGGAGACATAGCTTACTGGGACGAAGACGAACACTTCTTCATCG',
' TTGACCGCCTGAAGTCTCTGATTAAGTACAAAGGCTATCAGTGGCTCCCGCTGAATTGGAATCCATCTTGCTCCAACACCCCAACATCTTCGA',
' CGCAGGTGTGCGAGGTTCTCCGACGATGACGCCGTTGAACTTCCCGCCCGCTTGTGTTTTGGAGCACGGAAGACGATGACGAAAAAGAG',
' ATCGTGGATTACGTCCGAGTCAAGTAACAACCGCAAAAAAGTTGCGCGGAGGAGTTGTGTTTGTGGACGAAGTACCGAAAGGTCTTACCGGAA',
' AACTCGACGAAGAAAAATCAGAGAGATCCTCATAAAGGCCAAGAAGGGCGGAAGATCGCCGTG')

sdSeqStartPosition <- 1001
cdsNew <- increaseGTsiteStrength(cds, sdSeqStartPosition)
print(cdsNew)
```

ModCon	<i>ModCon</i>
--------	---------------

Description

Execute ModCon on a donor site within a coding sequence either increasing or decreasing its HZEI weight.

Usage

```
ModCon(cds, sdSeqStartPosition, upChangeCodonsIn=16, downChangeCodonsIn=16,
optimizeContext=TRUE, sdMaximalHBS=10, acMaximalMaxent=4, optiRate=100,
nGenerations=50, parentSize=300, startParentSize=1000, bestRate=40,
semiLuckyRate=20, luckyRate=5, mutationRate=1e-04, nCores=-1)
```

Arguments

cds	Character value of coding nucleotide sequence which holds the splice site of interest
sdSeqStartPosition	Numeric value of the position of the first nucleotide of the splice donor of interest
upChangeCodonsIn	Numeric value of number of codons to change upstream of the donor site of interest
downChangeCodonsIn	Numeric value of number of codons to change downstream of the donor site of interest
optimizeContext	Character value which determines, if TRUE (the default) the donor context will be adjusted to increase the splice site HEXplorer weight (SSH), if FALSE, the SSH will be decreased.
sdMaximalHBS	Numeric value of minimal HBS of SDs which should be tried to be degraded in their intrinsic strength
acMaximalMaxent	Numeric value of minimal MaxEntScan score of SAs which should be tried to be degraded in their intrinsic strength
optiRate	Numeric value setting level of HZEI integral optimization
nGenerations	Numeric value setting maximal number of generations
parentSize	Numeric value setting size of parent generations, generated from previous generations
startParentSize	Numeric value setting size of initiated parent generation of sequences
bestRate	Numeric value setting percentage how many of the fittest sequences are used to produce the next generation
semiLuckyRate	Numeric value setting percentage of sequences which are selected for breeding with a probability based on the respective HZEI-score integral
luckyRate	Numeric value setting percentage of sequences which are randomly selected for breeding

mutationRate	Numeric value setting chance of each codon, to mutate randomly within a child sequence
nCores	Numeric value setting number of cores which should be used for parallel computations. If set to '-1' all available cores are selected.

Value

Creates a character value of a coding nucleotide sequence encoding the same amino acid sequence as the entered cds, but with an alternative nucleotide surrounding around the splice donor (SD) sequence position, stated with sdSeqStartPosition. Depending on the entered optimizeContext, the SD surrounding is either adjusted aiming to enhance or decrease the splice site HEXplorer wheighth.

Examples

```
## Load R packages
library('parallel')
library('utils')
library('data.table')

## Set parameters for simplest use of ModCon (optimizing to 100%)
cds <- paste0('ATGGAAGACGCCAAAAACATAAAGAAAGGCCCGCCATTCTATCCGCTGGAAGATGGAACCGCTGGAGAGCAACTGCA',

'TAAGGCTATGAAGAGATACGCCCTGGTTCTGGAACAATTGCTTTTACAGATGCACATATCGAGGTGGACATCACTTACGCTGAGTACTTCGAAA',
'TGTCCGTTTCGGTTGGCAGAAGCTATGAAACGATATGGGCTGAATACAAATCACAGAATCGTCGTATGCAGTGAAAACCTCTTCAATTCTTTAT',
'GCCGGTGTGGGCGCCTTATTTATCGGAGTTGCAGTTGCGCCCGGAACGACATTTATAATGAACGTGAATTGCTCAACAGTATGGGCATTTG',
'CAGCCTACCGTGGTGTTCGTTTCCAAAAAGGGTTGCAAAAAATTTTGAACGTGCAAAAAAGCTCCAATCATCAAAAAATTATTATCATGG',
'ATTCATAAACCGGATTACCAGGGATTTTCAGTCGATGTACACGTTTCGTACATCTCATCTACCTCCCGGTTTTAATGAATACGATTTTGTGCCAGA',
'GTCCTTCGATAGGGACAAGACAATTGCACTGATCATGAACTCCTCTGGATCTACTGGCTGCCTAAAGGTGTCGCTCTGCCTCATAGAAGTCC',
'TGCGTGAGATTCTCGCATGCCAGAGATCCTATTTTTGGCAATCAAATCATTCCGGATACTGCGATTTTAAAGTGTGTTCCATTCCATCACGGT',
'TTGAATGTTTACTACACTCGGATATTTGATATGTGGATTCGAGTCGTCTTAATGTATAGATTTGAAGAAGAGCTGTTTCTGAGGAGCCTTCA',
'GGATTACAAGATTCAAAGTGCCTGCTGGTGCCAACCTATTCTCCTTCTTCGCCAAAAGCACTCTGATTGACAAATACGATTTATCTAATTTA',
'CACGAAATGCTTCTGGTGGCCTCCCTCTCTAAGGAAGTCGGGAAGCGGTTGCCAAGAGGTTCCATCTGCCAGGTATCAGGCAAGGATATG',
'GGCTCACTGAGACTACATCAGCTATTCTGATTACACCGAGGGGATGATAAACCGGGCGCGGTGCGTAAAGTTGTTCCATTTTTGAAGCGAA',
'GGTTGTGGATCTGGATACCGGAAAACGCTGGGCGTTAATCAAAGAGGCGAAGTGTGTGAGAGGTCCTATGATTATGTCCGGTTATGTAAC',
'AATCCGGAAGCGACCAACGCCTTGATTGACAAGGATGGATGGCTACATTTCTGGAGACATAGCTTACTGGGACGAAGACGAACTTCTTCATCG',
'TTGACCGCTGAAGTCTCTGATTAAGTACAAAGGCTATCAGGTGGCTCCCGCTGAATTGGAATCCATCTTGCTCCAACCCCAACATCTTGA',
'CGCAGGTGTCGCGAGTCTCCCGACGATGACCGCGTGAACCTCCCGCCCGGTTGTTGTTTTGGAGCACGGAAGACGATGACGGAAAAAGAG',
'ATCGTGGATTACGTCGCCAGTCAAGTAACAACCGCAAAAAAGTTCCGCGGAGGAGTTGTGTTTGTGGACGAAGTACCGAAAAGGTCTTACCGAA',
'AACTCGACCAAGAAAAATCAGAGAGATCCTCATAAAGGCCAAGAAGGCGGAAGATCGCCGTG')

## Execute ModCon
finalSequence <- ModCon(cds, 1001)

## Print final cds sequence with the alternative SD nucleotide surrounding
print(finalSequence)

## More parameters can be set for use of ModCon when not optimizing to 100% (e.g. 50%)

## Execute ModCon
finalSequence <- ModCon(cds, 1001, upChangeCodonsIn=16, downChangeCodonsIn=16,
optimizeContext=FALSE, sdMaximalHBS=10, acMaximalMaxent=4,
optiRate=50, nGenerations=5, parentSize=200, startParentSize=800,
```

```
bestRate=50, semiLuckyRate=10, luckyRate=5, mutationRate=1e-03, nCores=1)

## Print final cds sequence with the alternative SD nucleotide surrounding
print(finalSequence)
```

mutatePopulation *Randomly exchange codons within a set of sequences.*

Description

For every codon within a set of nucleotide sequences randomly exchange the codon encoding the same amino acid to a certain chance.

Usage

```
mutatePopulation(sequenceVector, codonReplacementChance)
```

Arguments

sequenceVector Character vector of nucleotide sequences (at least 3 nt long)
codonReplacementChance
 Numeric value of chance of a codons within the sequences to get exchanged to another codon encoding the same amino acid

Value

Creates a character vector of coding nucleotide sequences encoding the same amino acid sequence as the entered sequenceVector. By a mutation rate stated in codonReplacementChance, codons are randomly exchanged, by alternative codons encoding the same amino acid.

Examples

```
mutatePopulation(c("CGCGATACGCTAAGCGCTACCGATAGTGG", "TGGGATATTTAAGCGCTGACGATAGTGG"), 0.1)
```

recombineTwoSequences *Generate new sequence from recombination of two sequences*

Description

This function generates a new sequences through recombination of two parental sequences using 3 modi of recombination. Either random combination of codons, crossover recombination or insertion.

Usage

```
recombineTwoSequences(ntSequence1, ntSequence2, preferenceVector)
```

Arguments

ntSequence1	Character value of a nucleotide sequence
ntSequence2	Character value of a nucleotide sequence
preferenceVector	Numeric vector of length three which indicates which modus of recombination should be preferred. The first number states the chance of random recombination, the second number indicates the chance of cross-over recombination and the third number indicates the chance of insertion recombination.

Value

Character value of a nucleotide sequence, generated by recombination from the entered ntSequence1 and ntSequence2. Modes of recombination are cross-over, insertion and random and mode preferences can be stated by preferenceVector.

Examples

```
recombineTwoSequences("AGGGCCTGGAGGAGGCTT", "TAAGCAAGCCTGGACCC", c(1, 3, 2))
```

selectBestAndMean	<i>Select best HZEI and mean</i>
-------------------	----------------------------------

Description

From all sequences of a generation report highest HZEI integral and mean HZEI integral of all.

Usage

```
selectBestAndMean(sequenceVector, clusterName, increaseHZEI=TRUE)
```

Arguments

sequenceVector	Character vector of nucleotide sequences
clusterName	Name of cluster generated with package parallel
increaseHZEI	Logical value if HZEI integral should be increased or decreased during SD degradation. If TRUE, function aims to increase HZEI integral.

Value

Numeric vector of length 2 stating the best HZEI integral and the mean HZEI integral of a nucleotide sequence vector sequenceVector. Depending on the increaseHZEI mode, the best HZEI integral value is either the highest (for increaseHZEI==TRUE) or lowest (for increaseHZEI==FALSE).

Examples

```
## Setup cluster
library(parallel)
nCores <- 1
clust <- makeCluster(nCores)
clusterExport(clust, list('getOverlappingVectorsFromVector', 'hex',
'calculateHZEIint'), envir = environment())
selectBestAndMean(c('CGCGATACGCTAAGCGCTACCGATAGTGGGA', 'TGGGATATTTTAAGCGCTGACGATAGTGGGA'),
clust, increaseHZEI=TRUE)
```

```
selectMatingIndividuals
```

Selecting mating sequences from a pool of sequences

Description

Selecting sequences from a pool of nucleotide sequences based in chance and their HZEI integral.

Usage

```
selectMatingIndividuals(inputGeneration, whoMatesBestPercent=40, whoMatesSemiRandom=20,
whoMatesLuckyly=5, clust, increaseHZEI=TRUE)
```

Arguments

inputGeneration	Character vector of nucleotide sequences
whoMatesBestPercent	Numeric value e.g. 20 (which would mean that sequences with the top 20 percent highest HZEI integral are selected for mating)
whoMatesSemiRandom	Numeric value (is always lower than total number of sequences in input_generation)
whoMatesLuckyly	Numeric value (is always lower than total number of sequences in input_generation)
clust	Name of cluster generated with package parallel
increaseHZEI	Logical value of HZEI integral should be increased or decreased during SD degradation. If TRUE, function aims to increase HZEI integral.

Value

Character vector of nucleotide sequences which are selected from an entered vector of nucleotide sequences inputGeneration for creation of filial sequences by recombination. Sequences are selected by different criteria stated by whoMatesBestPercent, whoMatesSemiRandom, whoMatesLuckyly and increaseHZEI.

Examples

```
## Setup cluster
library(parallel)
nCores <- 1
clust <- makeCluster(nCores)
clusterExport(clust, list('getOverlappingVectorsFromVector',
'hex'), envir=environment())
selectMatingIndividuals(c('CGCGATACGCGCGATACG', 'CGCGATACGTGGGATATT',
'CTAAGCGCTCGCGATACG', 'CGCGATACGTTAAGCGCT', 'GACGATAGTCGCGATACG'),
whoMatesBestPercent=40, whoMatesSemiRandom=1, whoMatesLuckyily=1, clust, increaseHZEI=TRUE)
```

slidingWindowHZEImanipulation

Quickly manipulate HZEI integral of nucleotide sequence

Description

Quickly manipulate HZEI integral of nucleotide sequence (min. 21nt long)

Usage

```
slidingWindowHZEImanipulation(inSeq, increaseHZEI=TRUE)
```

Arguments

inSeq	Character value of nucleotide sequence (min 21nt long, only bases 'A', 'G', 'T' or 'C')
increaseHZEI	Logical value if HZEI integral should be increased or decreased during SD degradation. If TRUE, function aims to increase HZEI integral.

Value

Character value of a nucleotide sequence encoding the same amino acid sequence as inSeq, but an increased HZEI integral, due to alternative codon selection, accomplished through sliding window optimization.

Examples

```
# Load R packages
library('parallel')
library('utils')
library('data.table')

# Set parameters for genetic algorithm
inSeq <- 'ATGGAAGACGCCAAAACATAAAGAAAGCGAGGCTAAGCCTAGCTTGCCATTGCCCGGCGCCATTCTATCCGCTGGAAGATGGAATT'

maximizedHZEIseq <- slidingWindowHZEImanipulation(inSeq, increaseHZEI=TRUE)
minimizedHZEIseq <- slidingWindowHZEImanipulation(inSeq, increaseHZEI=FALSE)

#Access sequence with maximized HZEI intregral
maximizedHZEIseq
```

```
#Access sequence with minimized HZEI integral  
minimizedHZEIseq
```

startModConApp *Start GUI of VarCon.*

Description

Start graphical user interface for the ModCon application.

Usage

```
startModConApp()
```

Value

Shiny app

Examples

```
startModConApp()
```

Index

* datasets

- cds, [3](#)
- Codons, [5](#)
- hbg, [11](#)
- hex, [11](#)

- calculateHZEIint, [2](#)
- calculateMaxEntScanScore, [3](#)
- cds, [3](#)
- changeSequenceHZEI, [4](#)
- Codons, [5](#)
- createCodonMatrix, [6](#)
- createFilialSequencePopulation, [6](#)

- decreaseGTsiteStrength, [7](#)
- degradeSAs, [8](#)
- degradeSDs, [9](#)

- generateRandomCodonsPerAA, [9](#)
- getOverlappingVectorsFromVector, [10](#)

- hbg, [11](#)
- hex, [11](#)

- increaseGTsiteStrength, [12](#)

- ModCon, [13](#)
- mutatePopulation, [15](#)

- recombineTwoSequences, [15](#)

- selectBestAndMean, [16](#)
- selectMatingIndividuals, [17](#)
- slidingWindowHZEImanipulation, [18](#)
- startModConApp, [19](#)