Package ‘cubfits’

November 7, 2021

Version 0.1-4
Date 2021-11-06
Title Codon Usage Bias Fits
Depends R(>= 4.0.0), methods, coda, foreach, parallel, stats, graphics, utils
Suggests seqinr, VGAM, EMCluster
Enhances pbdMPI (>= 0.3-1)
LazyLoad yes
LazyData yes
Description Estimating mutation and selection coefficients on synonymous codon bias usage based on models of ribosome overhead cost (ROC). Multinomial logistic regression and Markov Chain Monte Carlo are used to estimate and predict protein production rates with/without the presence of expressions and measurement errors. Work flows with examples for simulation, estimation and prediction processes are also provided with parallelization speedup. The whole framework is tested with yeast genome and gene expression data of Yassour, et al. (2009) <doi:10.1073/pnas.0812841106>.
License Mozilla Public License 2.0
BugReports https://github.com/snoweye/cubfits/issues
URL https://github.com/snoweye/cubfits
NeedsCompilation yes
Maintainer Wei-Chen Chen <wccsnow@gmail.com>
Author Wei-Chen Chen [aut, cre], Russell Zaretzki [aut], William Howell [aut], Cedric Landerer [aut], Drew Schmidt [aut], Michael A. Gilchrist [aut], Preston Hewgley [ctb], Students REU13 [ctb]
cubfits-package

Repository CRAN
Date/Publication 2021-11-07 17:20:02 UTC

R topics documented:

- cubfits-package ............................................. 2
- Asymmetric Laplace Distribution .......................... 4
- Cedric Convergence Utilities .............................. 6
- Cedric IO Utilities .......................................... 7
- Cedric Plot Utilities ......................................... 8
- Codon Adaptation Index ................................... 10
- Controls ...................................................... 11
- Coverting Utility ........................................... 14
- CUB Model Approximation .................................. 16
- CUB Model Fits .............................................. 18
- CUB Model Prediction ....................................... 20
- Data Formats ................................................ 23
- Datasets ...................................................... 24
- Estimate Phi .................................................. 26
- Fit Multinomial .............................................. 27
- Generating Utility .......................................... 29
- Initial Generic Functions ................................... 30
- Input and Output Utility .................................... 33
- Mixed Normal Optimization ............................... 34
- Plotbin ....................................................... 36
- Plotmodel ..................................................... 37
- Plotprxy ....................................................... 39
- Posterior Results of Yassour2009 ......................... 40
- Print ......................................................... 41
- Randomize SCUO Index ..................................... 42
- Rearrangment Utility ........................................ 44
- SCUO Index ................................................... 45
- Selection on Codon Usage ................................... 46
- Simulation Tool .............................................. 47
- Yassour2009 .................................................. 49

Index 51

| cubfits-package | Codon Bias Usage Fits |

Description

Estimating mutation and selection coefficients on synonymous codon bias usage based on models of ribosome overhead cost (ROC). Multinomial logistic regression and Markov Chain Monte Carlo are used to estimate and predict protein production rates with/without the presence of expressions and measurement errors.
Details

Package: cubfits
Type: Package
License: Mozilla Public License 2.0
LazyLoad: yes

The install command is simply as

> R CMD INSTALL cubfits_*.tar.gz

from a command mode or

R> install.packages("cubfits")

inside an R session.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>, Russell Zaretzki, William Howell, Drew Schmidt, and Michael Gilchrist.

References

https://github.com/snoweye/cubfits/

See Also

init.function(), cubfits(), cubpred(), and cubappr().

Examples

## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

demo(roc.train, 'cubfits', ask = F, echo = F)
demo(roc.pred, 'cubfits', ask = F, echo = F)
demo(roc.appr, 'cubfits', ask = F, echo = F)

## End(Not run)
Asymmetric Laplace Distribution

The Asymmetric Laplace Distribution

Description

Density, probability, quantile, random number generation, and MLE functions for the asymmetric Laplace distribution with parameters either in $\text{ASL}(\theta, \mu, \sigma)$ or the alternative $\text{ASL}^*(\theta, \kappa, \sigma)$.

Usage

\[
\begin{align*}
\text{dasl}(x, \theta = 0, \mu = 0, \sigma = 1, \log = \text{FALSE}) \\
\text{dasla}(x, \theta = 0, \kappa = 1, \sigma = 1, \log = \text{FALSE}) \\
\text{pasl}(q, \theta = 0, \mu = 0, \sigma = 1, \text{lower.tail} = \text{TRUE}, \text{log.p} = \text{FALSE}) \\
\text{pasla}(q, \theta = 0, \kappa = 1, \sigma = 1, \text{lower.tail} = \text{TRUE}, \text{log.p} = \text{FALSE}) \\
\text{qasl}(p, \theta = 0, \mu = 0, \sigma = 1, \text{lower.tail} = \text{TRUE}, \text{log.p} = \text{FALSE}) \\
\text{qasla}(p, \theta = 0, \kappa = 1, \sigma = 1, \text{lower.tail} = \text{TRUE}, \text{log.p} = \text{FALSE}) \\
\text{rasl}(n, \theta = 0, \mu = 0, \sigma = 1) \\
\text{rasla}(n, \theta = 0, \kappa = 1, \sigma = 1) \\
\text{asl.optim}(x)
\end{align*}
\]

Arguments

\[
\begin{align*}
x, q & \quad \text{vector of quantiles.} \\
p & \quad \text{vector of probabilities.} \\
n & \quad \text{number of observations. If } \text{length}(n) > 1, \text{the length is taken to be the number required.} \\
\theta & \quad \text{center parameter.} \\
\mu, \kappa & \quad \text{location parameters.} \\
\sigma & \quad \text{shape parameter.} \\
\log, \log.p & \quad \text{logical; if TRUE, probabilities } p \text{ are given as log}(p). \\
\text{lower.tail} & \quad \text{logical; if TRUE (default), probabilities are } P[X \leq x] \text{ otherwise, } P[X > x].
\end{align*}
\]
Asymmetric Laplace Distribution

Details

The density \( f(x) \) of \( \text{ASL}^*(\theta, \kappa, \sigma) \) is given as
\[
\frac{\sqrt{2}}{\sigma} \frac{\kappa}{1+\kappa^2} e^{-\sqrt{\frac{2\kappa}{\sigma}} |x-\theta|} \text{if } x \geq \theta,
\]
and
\[
\frac{\sqrt{2}}{\sigma} \frac{\kappa}{1+\kappa^2} e^{-\frac{\sqrt{2\kappa}}{\sigma\kappa} |x-\theta|} \text{if } x < \theta.
\]

The parameter domains of \( \text{ASL} \) and \( \text{ASL}^* \) are \( \theta \in \mathbb{R}, \sigma > 0, \kappa > 0, \) and \( \mu \in \mathbb{R}. \) The relation of \( \mu \)
and \( \kappa \) are
\[
\kappa = \frac{\sqrt{2\sigma^2 + \mu^2 - \mu}}{\sqrt{2\sigma}} \quad \text{or} \quad \mu = \frac{\sigma}{\sqrt{2}} \left( \frac{1}{\kappa} - \kappa \right).
\]

Value

“dasl” and “dasla” give the densities, “pasl” and “pasla” give the distribution functions, “qasl” and “qasla” give the quantile functions, and “rasl” and “rasls” give the random numbers.

`asl.optim` returns the MLE of data \( x \) including \( \theta, \mu, \kappa, \) and \( \sigma. \)

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.

References


Examples

```r
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))
set.seed(1234)

dasl(-2:2)
dasl(-2:2)
pasl(-2:2)
pasl(-2:2)
qasl(seq(0, 1, length = 5))
qasla(seq(0, 1, length = 5))

dasl(-2:2, log = TRUE)
dasl(-2:2, log = TRUE)
pasl(-2:2, log.p = TRUE)
pasl(-2:2, log.p = TRUE)
qasl(log(seq(0, 1, length = 5)), log.p = TRUE)
qasla(log(seq(0, 1, length = 5)), log.p = TRUE)

set.seed(123)
rasl(5)
rasl(5)

asl.optim(rasl(5000))
## End(Not run)
```
Description

This utility function provides convergence related functions by Cedric.

Usage

```r

cubmultichain(cubmethod, reset.qr, seeds=NULL, 
        teston=c("phi", "sphi"), swap=0, swapAt=0.05, monitor=NULL, 
        min=0, max=160000, nchains=2, conv.thin=10, 
        eps=0.1, ncores=2, ...)

cubsinglechain(cubmethod, frac1=0.1, frac2=0.5, reset.qr, 
            seed=NULL, teston=c("phi", "sphi"), monitor=NULL, 
            min=0, max=160000, conv.thin=10, eps=1, ...)
```

Arguments

cubmethod String to choose method. Options are "cubfits", "cubappr", "cubpred"
reset.qr recalculate QR decomposition matrix of covariance matrix until reset.qr samples are reached
swap proportion of b matrix parameters to be swaped between convergence checks
swapAt difference (L1-norm) between two consequtive convergence test leading to a swap in the b matrix
seeds Vector of seed for random number generation
seed Seed for random number generation
teston Select data to test convergence on
monitor A function to monitor the progress of the MCMC. The function expects the result object and for cubmultichain an index i. (cubmultichain call: monitor(x,i), cubsinglechain call: monitor(x))
min Minimum samples to be obtained. eps is ignored until number of samples reaches min
max Maximum samples to be obtained. eps is ignored after max samples is obtained
eps Convergence criterium
conv.thin thinning of samples before performing convergence test
nchains number of chains to run in parallel
ncores number of cores to use for parallel execution of chains
frac1 fraction of samples at the beginning of set for Geweke test
frac2 fraction of samples at the end of set for Geweke test
... named arguments for functions "cubfits", "cubappr" or "cubpred"
Details
under development

Value
under development

Author(s)
Cedric Landerer <cedric.landerer@gmail.com>.

References
https://github.com/clandere/cubfits/

See Also
cubfits, cubappr, cubpred

Examples
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

## End(Not run)

Description
This utility function provides basic IO by Cedric.

Usage
readGenome(fn.genome, ex.sh.aa = 0, rm.first.aa = 0)
normalizeDataSet(data)

Arguments
fn.genome Fasta file with sequences
ex.sh.aa Ignore sequences with a length less than ex.sh.aa. (After removal of the first
rm.first.aa amino acids)
rm.first.aa Remove the first rm.first.aa amino acids (after start codon)
data Vector to be normalized. Means will be set to 1
Details
under development

Value
under development

Author(s)
Cedric Landerer <cedric.landerer@gmail.com>.

References
https://github.com/clandere/cubfits/

See Also
under development

Examples
```r
## Not run:
library(cubfits)
seq.string <- readGenome("my_genome.fasta", 150, 10)

## End(Not run)
```

Description
This utility function provides basic plots by Cedric.

Usage
```r
plotPTraces(pMat, ...)

plotExpectedPhiTrace(phiMat, ...)

plotCUB(reu13.df.obs, bMat = NULL, bVec = NULL, phi.bin,
        n.use.samples = 2000, main = "CUB", model.label = c("True Model"),
        model.lty = 1, weightedCenters = TRUE)

plotTraces(bMat, names.aa, param = c("logmu", "deltaeta", "deltat"),
          main = "AA parameter trace")
```
Arguments

- `reu13.df.obs` under development
- `bVec` a parameter vector
- `phi.bin` phi values to bin for comparison
- `n.use.samples` under development
- `main` Main name for plotTraces
- `model.label` Name of model
- `model.lty` line type for model
- `weightedCenters` if centers are weighted.
- `names.aa` List of amino acids used for estimation
- `param` select to plot parameter trace for either log(mu) values or delta t
- `phiMat` phi matrix from the output of "cubmultichain", "cubsinglechain", "cubfits", "cubappr", or "cubpred"
- `bMat` b matrix from the output of "cubmultichain", "cubsinglechain", "cubfits", "cubappr", or "cubpred"
- `pMat` p matrix from the output of "cubmultichain", "cubsinglechain", "cubfits", "cubappr", or "cubpred"
- `...` other plotting options

Details

under development

Value

under development

Author(s)

Cedric Landerer <cedric.landerer@gmail.com>.

References

https://github.com/clandere/cubfits/

See Also

plot

Examples

```r
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

## End(Not run)
```
Codon Adaptation Index

Function for Codon Adaptation Index (CAI)

Description
Calculate the Codon Adaptation Index (CAI) for each gene. Used as a substitute for expression in cases of without expression measurements.

Usage
```r
calc_cai_values(y, y.list, w = NULL)
```

Arguments
- `y`: an object of format `y`.
- `y.list`: an object of format `y.list`.
- `w`: a specified relative frequency of synonymous codons.

Details
This function computes CAI for each gene. Typically, this method is completely based on entropy and information theory to estimate expression values of sequences according to their codon information.

If the input `w` is `NULL`, then empirical values are computed.

Value
A list with two named elements `CAI` and `w` are returned where `CAI` are CAI of input sequences (`y` and `y.list`) and `w` are the relative frequency used to computed those CAI’s.

Author(s)
Wei-Chen Chen <wccsnow@gmail.com>.

References

See Also
`calc_scuo_values()`, `calc_scu_values()`.
Controls

Default Controlling Options

<table>
<thead>
<tr>
<th>Description</th>
<th>Default controls of {cubfits} include for models, optimizations, MCMC, plotting, global variables, etc.</th>
</tr>
</thead>
</table>

Examples

```r
## Not run:
rm(list = ls())
library(cubfits, quietly = TRUE)

y <- ex.train$y
y.list <- convert.y.to.list(y)
CAI <- calc_cai_values(y, y.list)$CAI
plot(CAI, log10(ex.train$phi.Obs), main = "Expression vs CAI",
     xlab = "CAI", ylab = "Expression (log10)"
)

### Verify with the seqinr example.
library(seqinr, quietly = TRUE)
inputdatfile <- system.file("sequences/input.dat", package = "seqinr")
input <- read.fasta(file = inputdatfile, forceDNAtolower = FALSE)
names(input)[65] <- paste(names(input)[65], ".1", sep = "") # name duplicated.
input <- input[order(names(input))]

### Convert to cubfits format.
seq.string <- convert.seq.data.to.string(input)
new.y <- gen.y(seq.string)
new.y.list <- convert.y.to.list(new.y)
ret <- calc_cai_values(new.y, new.y.list)

### Rebuild w.
w <- rep(1, 64)
names(w) <- codon.low2up(rownames(caitab))
for(i in 1:64){
  id <- which(names(ret$w) == names(w)[i])
  if(length(id) == 1){
    w[i] <- ret$w[id]
  }
}
CAI.res <- sapply(input, seqinr::cai, w = w)

### Plot.
plot(CAI.res, ret$CAI,
     main = "Comparison of seqinR and cubfits results",
     xlab = "CAI from seqinR", ylab = "CAI from cubfits", las = 1)
abline(c(0, 1))

## End(Not run)
```
Usage

```
.cubfitsEnv
.CF.CT
.CF.CONF
.CF.GV
.CF.DP
.CF.OP
.CF.AC
.CF.PT
.CF.PARAM
.CO.CT
```

Format

All are in lists and contain several controlling options.

Details

See `init.function()` for use cases of these objects.

- `.cubfitEnv` is a default environment to dynamically save functions and objects.
- `.CF.CT` is main controls of models. It currently includes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>model</td>
<td>main models</td>
</tr>
<tr>
<td>type.p</td>
<td>proposal for hyper-parameters</td>
</tr>
<tr>
<td>type.Phi</td>
<td>proposal for Phi</td>
</tr>
<tr>
<td>model.Phi</td>
<td>prior of Phi</td>
</tr>
<tr>
<td>init.Phi</td>
<td>initial methods for Phi</td>
</tr>
<tr>
<td>init.fit</td>
<td>how is coefficient proposed</td>
</tr>
<tr>
<td>parallel</td>
<td>parallel functions</td>
</tr>
<tr>
<td>adaptive</td>
<td>method for adaptive MCMC</td>
</tr>
</tbody>
</table>

- `.CF.CONF` controls the initial and draw scaling. It currently includes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>scale.phi.Obs</td>
<td>if phi were scaled to mean 1</td>
</tr>
<tr>
<td>init.b.Scale</td>
<td>initial b scale</td>
</tr>
<tr>
<td>init.phi.Scale</td>
<td>initial phi scale</td>
</tr>
<tr>
<td>p.nclass</td>
<td>number of classes if mixture phi</td>
</tr>
<tr>
<td>b.DrawScale</td>
<td>drawing scale for b if random walk</td>
</tr>
<tr>
<td>p.DrawScale</td>
<td>drawing scale for p if random walk</td>
</tr>
<tr>
<td>phi.DrawScale</td>
<td>random walk scale for phi</td>
</tr>
<tr>
<td>phi.pred.DrawScale</td>
<td>random walk scale for phi.pred</td>
</tr>
<tr>
<td>sigma.Phi.DrawScale</td>
<td>random walk scale for sigma.Phi</td>
</tr>
<tr>
<td>bias.Phi.DrawScale</td>
<td>random walk scale for bias.Phi</td>
</tr>
<tr>
<td>estimate.bias.Phi</td>
<td>if estimate bias of phi during MCMC</td>
</tr>
<tr>
<td>compute.logL</td>
<td>if compute logL in each iteration</td>
</tr>
</tbody>
</table>

- `.CF.GV` contains global variables for amino acids and codons. It currently includes
controls

- **amino.acid** amino acids
- **amino.acid.3** amino acids
- **synonymous.codon** synonymous codons of amino acids
- **amino.acid.split** amino acid 'S' is split
- **amino.acid.split.3** amino acid 'S' is split
- **synonymous.codon.split** synonymous codons of split amino acid

- **.CF.OP** controls optimizations. It currently includes

  - **optim.method** method for optim()
  - **stable.min.exp** minimum exponent
  - **stable.max.exp** maximum exponent
  - **E.Phi** expected Phi
  - **lower.optim** lower of derivative of logL(x)
  - **upper.optim** upper of derivative of logL(x)
  - **lower.integrate** lower of integration of L(x)
  - **upper.integrate** upper of integration of L(x)

- **.CF.DP** is for dumping MCMC iterations. It currently includes

  - **dump** if dumping within MCMC
  - **iter** iterations per dumping
  - **prefix.dump** path and file names of dumping
  - **verbose** if verbose
  - **iterThin** iterations to thin chain
  - **report** iterations to report
  - **report.proc** iterations to report proc.time()

- **.CF.AC** controls adaptive MCMC. It currently includes

  - **renew.iter** per renewing iterations
  - **target.accept.lower** target acceptant rate lower bound
  - **target.accept.upper** target acceptant rate upper bound
  - **scale.increase** increase scale size
  - **scale.decrease** decrease scale size
  - **sigma.lower** lower bound of relative scale size
  - **sigma.upper** upper bound of relative scale size

- **.CF.PT** controls the plotting format. It currently includes

  - **color** color for codons.

- **.CF.PARAM** controls the parameters and hyperparameters of priors. It currently includes

  - **phi.meanlog** mean of phi in loca scale
  - **phi.sdlog** standard deviation of phi in loca scale

- **.CO.CT** controls the constrained optimization function. It currently includes
Covering Utility

debug message printing level of debugging.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.

References

https://github.com/snoweye/cubfits/

See Also

init.function(), cubfits(), cubpred(), cubappr(), and mixnormerr.optim().

Examples

## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

.CF.CT
.CF.CONF
.CF.DP
.CF.GV
.CF.OP
.CF.AC
.CF.PT
.CF.PARAM
.CO.CT

ls(.cubfitsEnv)
init.function()
ls(.cubfitsEnv)

## End(Not run)

Covering Utility  Convert Data Frame to Other Formats

Description

These utility functions convert data of format divided by amino acids into list of format divided by ORFs, or convert data to other formats.

Usage

convert.reu13.df.to.list(reu13.df)
convert.y.to.list(y)
convert.n.to.list(n)
Converting Utility

convert.y.to.scuo(y)
convert.seq.data.to.string(seq.data)

codon.low2up(x)
codon.up2low(x)

dna.low2up(x)
dna.up2low(x)

convert.b.to.bVec(b)
convert.bVec.to.b(bVec, aa.names, model = .CF.CT$model[1])

Arguments

reu13.df      a list of reu13.df data frames divided by amino acids.
y           a list of y data frames divided by amino acids.
n           a list of n vectors divided by amino acids.
seq.data     a vector of seq.data format.
x           a codon or dna string, such "ACG", "acg", or "A", "a".
b           a b object.
bVec         a bVec object.
aa.names    a vector contains amino acid names for analysis.
model      model fitted.

Details

convert.reu13.df.to.list(), convert.y.to.list(), and convert.n.to.list(): these utility functions take the inputs divided by amino acids and return the outputs divided by ORFs.
convert.y.scuo() converts y into scuo format.
convert.seq.data.to.string() converts seq.data into seq.string format.
codon.low2up() and codon.up2low() convert codon strings between lower or upper cases.
convert.bVec.to.b() and convert.b.to.bVec() convert objects b and bVec.

Value

All functions return the corresponding formats.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.

References

https://github.com/snoweye/cubfits/
See Also

AllDataFormats, rearrange.n(), rearrange.reu13.df(), rearrange.y(), and read.seq().

Examples

```r
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

reu13.list <- convert.reu13.df.to.list(ex.train$reu13.df)
y.list <- convert.y.to.list(ex.train$y)
n.list <- convert.n.to.list(ex.train$n)

scuo <- convert.y.to.scuo(ex.train$y)

seq.data <- read.seq(get.expath("seq_200.fasta"))
seq.string <- convert.seq.data.to.string(seq.data)

codon.low2up("acg")
codon.up2low("ACG")

dna.low2up(c("a", "c", "g"))
dna.up2low(c("A", "C", "G"))

## End(Not run)
```

CUB Model Approximation

Codon Usage Bias Approximation for ORFs without Expression

Description

This function provides codon usage bias approximation with observed ORFs but without any expressions.

Usage

```r
cubappr(reu13.df.obs, phi.pred.Init, y, n, 
nIter = 1000, 
b.Init = NULL, init.b.Scale = .CF.CONF$init.b.Scale, 
  b.DrawScale = .CF.CONF$b.DrawScale, 
  b.RInit = NULL, 
p.Init = NULL, p.nclass = .CF.CONF$p.nclass, 
  p.DrawScale = .CF.CONF$p.DrawScale, 
phi.pred.DrawScale = .CF.CONF$phi.pred.DrawScale, 
model = .CF.CT$model[1], model.Phi = .CF.CT$model.Phi[1], 
adaptive = .CF.CT$adaptive[1], 
verbose = .CF.DP$verbose, 
iternThin = .CF.DP$iterThin, report = .CF.DP$report)
```
Arguments

- **reu13.df.obs**
  - a `reu13.df` object, ORFs information.
- **phi.pred.Init**
  - a `phi.Obs` object, temporarily initial of expression without measurement errors.
- **y**
  - a `y` object, codon counts.
- **n**
  - a `n` object, total codon counts.
- **nIter**
  - number of iterations after burn-in iterations.
- **b.Init**
  - initial values for parameters `b`.
- **init.b.Scale**
  - for initial `b` if `b.Init = NULL`.
- **b.DrawScale**
  - scaling factor for adaptive MCMC with random walks when drawing new `b`.
- **b.RInit**
  - initial values (in a list) for R matrices of parameters `b` yielding from QR decomposition of `vglm()` for the variance-covariance matrix of `b`.
- **p.Init**
  - initial values for hyper-parameters.
- **p.nclass**
  - number of components for model.Phi = "logmixture".
- **p.DrawScale**
  - scaling factor for adaptive MCMC with random walks when drawing new `sigma.Phi`.
- **phi.pred.DrawScale**
  - scaling factor for adaptive MCMC with random walks when drawing new Phi of predicted set.
- **model**
  - model to be fitted, currently "roc" only.
- **model.Phi**
  - prior model for Phi, currently "lognormal".
- **adaptive**
  - adaptive method of MCMC for proposing new `b` and Phi.
- **verbose**
  - print iteration messages.
- **iterThin**
  - thinning iterations.
- **report**
  - number of iterations to report more information.

Details

Total number of MCMC iterations is `nIter + 1`, but the outputs may be thinned to `nIter / iterThin + 1` iterations.

Temporary result dumping may be controlled by `.CF.DP`.

Value

A list contains three big lists of MCMC traces including: `b.Mat` for mutation and selection coefficients of `b`, `p.Mat` for hyper-parameters, and `phi.Mat` for expected expression values Phi. All lists are of length `nIter / iterThin + 1` and each element contains the output of each iteration.

All lists also can be binded as trace matrices, such as via `do.call("rbind", b.Mat)` yielding a matrix of dimension number of iterations by number of parameters. Then, those traces can be analyzed further via other MCMC packages such as `coda`.

Note

Note that `phi.pred.Init` need to be normalized to mean 1.

`p.DrawScale` may cause scaling prior if adaptive MCMC is used, and it can result in non-exits of equilibrium distribution.
CUB Model Fits

Codon Usage Bias Fits for Observed ORFs and Expression

Description

This function provides codon usage bias fits with observed ORFs and expressions which possibly contains measurement errors.

Usage

```r
cubfits(reu13.df.obs, phi.Obs, y, n,
       nIter = 1000,
       b.Init = NULL, init.b.Scale = .CF.CONF$init.b.Scale,
       b.DrawScale = .CF.CONF$b.DrawScale,
       b.RInit = NULL,
       p.Init = NULL, p.nclass = .CF.CONF$p.nclass,
       p.DrawScale = .CF.CONF$p.DrawScale,
       phi.Init = NULL, init.phi.Scale = .CF.CONF$init.phi.Scale,
       phi.DrawScale = .CF.CONF$phi.DrawScale,
       model = .CF.CT$model[1], model.Phi = .CF.CT$model.Phi[1],
       adaptive = .CF.CT$adaptive[1],
       verbose = .CF.DP$verbose,
       iterThin = .CF.DP$iterThin, report = .CF.DP$report)
```
Arguments

- `reu13.df.obs` - a `reu13.df` object, ORFs information.
- `phi.Obs` - a `phi.Obs` object, expression with measurement errors.
- `y` - a `y` object, codon counts.
- `n` - a `n` object, total codon counts.
- `nIter` - number of iterations after burn-in iterations.
- `b.Init` - initial values for parameters `b`.
- `init.b.Scale` - for initial `b` if `b.Init = NULL`.
- `b.RInit` - initial values (in a list) for R matrices of parameters `b` yielding from QR decomposition of `vglm()` for the variance-covariance matrix of `b`.
- `p.Init` - initial values for hyper-parameters.
- `p.nclass` - number of components for `model.Phi = "logmixture"`.
- `phi.Init` - initial values for Phi.
- `init.phi.Scale` - for initial phi if `phi.Init = NULL`.
- `model` - model to be fitted, currently "roc" only.
- `model.Phi` - prior model for Phi, currently "lognormal".
- `adaptive` - adaptive method of MCMC for proposing new `b` and Phi.
- `verbose` - print iteration messages.
- `iterThin` - thinning iterations.
- `report` - number of iterations to report more information.

Details

This function correctly and carefully implements a combining version of Shah and Gilchrist (2011) and Wallace et al. (2013).

Total number of MCMC iterations is `nIter + 1`, but the outputs may be thinned to `nIter / iterThin + 1` iterations.

Temporary result dumping may be controlled by `.CF.DP`.

Value

A list contains three big lists of MCMC traces including: `b.Mat` for mutation and selection coefficients of `b`, `p.Mat` for hyper-parameters, and `phi.Mat` for expected expression values Phi. All lists are of length `nIter / iterThin + 1` and each element contains the output of each iteration.

All lists also can be binded as trace matrices, such as via `do.call("rbind",b.Mat)` yielding a matrix of dimension number of iterations by number of parameters. Then, those traces can be analyzed further via other MCMC packages such as `coda`. 
Note

Note that phi.Init need to be normalized to mean 1.

p.DrawScale may cause scaling prior if adaptive MCMC is used, and it can result in non-exits of equilibrium distribution.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.

References

https://github.com/snoweye/cubfits/


See Also

DataIO, DataConverting, cubapppr() and cubpred().

Examples

```r
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

demo(roc.train, 'cubfits', ask = F, echo = F)

## End(Not run)
```

Description

This function provides codon usage bias fits of training set which has observed ORFs and expressions possibly containing measurement errors, and provides predictions of testing set which has other observed ORFs but without expression.
Usage

cubpred(reu13.df.obs, phi.Obs, y, n,
    reu13.df.pred, y.pred, n.pred,
    nIter = 1000,
    b.Init = NULL, init.b.Scale = .CF.CONF$init.b.Scale,
    b.DrawScale = .CF.CONF$b.DrawScale,
    b.RInit = NULL,
    p.Init = NULL, p.nclass = .CF.CONF$p.nclass,
    p.DrawScale = .CF.CONF$p.DrawScale,
    phi.Init = NULL, init.phi.Scale = .CF.CONF$init.phi.Scale,
    phi.DrawScale = .CF.CONF$phi.DrawScale,
    phi.pred.Init = NULL,
    phi.pred.DrawScale = .CF.CONF$phi.pred.DrawScale,
    model = .CF.CT$model[1], model.Phi = .CF.CT$model.Phi[1],
    adaptive = .CF.CT$adaptive[1],
    verbose = .CF.DP$verbose,
    iterThin = .CF.DP$iterThin, report = .CF.DP$report)

Arguments

reu13.df.obs a reu13.df to be trained.
phi.Obs a phi.Obs to be trained.
y a y to be trained.
n a n to be trained.
reu13.df.pred a reu13.df to be predicted.
y.pred a y to be predicted.
n.pred a n to be predicted.
nIter number of iterations after burn-in iterations.
b.Init initial values for parameters b.
init.b.Scale for initial b if b.Init = NULL.
b.DrawScale scaling factor for adaptive MCMC with random walks when drawing new b.
b.RInit initial values (in a list) for R matrices of parameters b yielding from QR decomposition of vglm() for the variance-covariance matrix of b.
p.Init initial values for hyper-parameters.
p.nclass number of components for model.Phi = "logmixture".
phi.Init initial values for Phi.
init.phi.Scale for initial phi if phi.Init = NULL.
phi.DrawScale scaling factor for adaptive MCMC with random walks when drawing new Phi.
phi.pred.Init initial values for Phi of predicted set.
phi.pred.DrawScale as phi.DrawScale but for predicted set.
model to be fitted, currently "roc" only.

model.Phi prior model for Phi, currently "lognormal".

adaptive adaptive method of MCMC for proposing new b and Phi.

verbose print iteration messages.

iterThin thinning iterations.

report number of iterations to report more information.

Details

This function correctly and carefully implements an extension of Shah and Gilchrist (2011) and Wallace et al. (2013).

Total number of MCMC iterations is nIter + 1, but the outputs may be thinned to nIter / iterThin + 1 iterations.

Temporary result dumping may be controlled by .CF.DP.

Value

A list contains four big lists of MCMC traces including: b.Mat for mutation and selection coefficients of b, p.Mat for hyper-parameters, phi.Mat for expected expression values Phi, and phi.pred.Mat for predictive expression values Phi. All lists have nIter / iterThin + 1 elements, and each element contains the output of each iteration.

All lists also can be binded as trace matrices, such as via do.call("rbind",b.Mat) yielding a matrix of dimension number of iterations by number of parameters. Then, those traces can be analyzed further via other MCMC packages such as coda.

Note

Note that phi.Init and phi.pred.Init need to be normalized to mean 1.

p.DrawScale may cause scaling prior if adaptive MCMC is used, and it can result in non-exits of equilibrium distribution.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.

References

https://github.com/snoweye/cubfits/


See Also

DataIO, DataConverting, cubfits() and cubappr().
Examples

```r
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))
demo(roc.pred, 'cubfits', ask = F, echo = F)
## End(Not run)
```

Data Formats

Data formats used in `cubfits`.

Format

All are in simple formats as S3 default lists or data frames.

Details

- **Format b**: A named list `A` contains amino acids. Each element of the list `A[[i]]` is a list of elements coefficients (coefficients of log(mu) and Delta.t), `coef.mat` (matrix format of coefficients), and `R` (covariance matrix of coefficients). Note that coefficients and `R` are typically as in the output of `vglm()` of `VGAM` package. Also, `coef.mat` and `R` may miss in some cases. e.g. `A[[i]]$coef.mat` is the regression beta matrix of `i`-th amino acid.

- **Format bVec**: A vector simply contains all coefficients of a `b` object `A`. Note that this is probably only used inside MCMC or the output of `vglm()` of `VGAM` package. e.g. `do.call("c",lapply(A,function(x) x$coefficients))`.

- **Format n**: A named list `A` contains amino acids. Each element of the list `A[[i]]` is a vector containing total codon counts. e.g. `A[[i]][j]` is for `j`-th ORF of `i`-th amino acid `names(A)[i]`.

- **Format n.list**: A named list `A` contains ORFs. Each element of the list `A[[i]]` is a named list of amino acid containing total count. e.g. `A[[i]][[j]]` contains total count of `j`-th amino acid in `i`-th ORF.

- **Format phi.df**: A data frame `A` contains two columns ORF and `phi.value`. e.g. `A[i,]` is for `i`-th ORF.

- **Format reu13.df**: A named list `A` contains amino acids. Each element is a data frame summarizing ORF and expression. The data frame has four to five columns including ORF, `phi` (expression), `Pos` (amino acid position), `Codon` (synonymous codon), and `Codon.id` (synonymous codon id, for
Datasets computing only). Note that Codon.id may miss in some cases.
e.g. A[[i]][17,] is the 17-th recode of i-th amino acid.

• Format reu13.list:
  A named list A contains ORFs. Each element is a named list A[[i]] contains amino acids. 
  Each element of nested list A[[i]][[j]] is a position vector of synonymous codon. 
  e.g. A[[i]][[j]][k] is the k-th synonymous codon position of j-th amino acid in the i-th ORF.

• Format scuo:
  A data frame of 8 named columns includes AA (amino acid), ORF, C1, ..., C6 where C*’s are for codon counts.

• Format seq.string:
  Default outputs of read.fasta() of seqinr package. A named list A contains ORFs. Each 
  element of the list is a long string of a ORF. 
  e.g. A[[i]][1] or A[[i]] is the sequence of i-th ORF.

• Format seq.data:
  Converted from seq.string format. A named list A contains ORFs. Each element of the list 
  A[[i]] is a string vector. Each element of the vector is a codon string. 
  e.g. A[[i]][j] is i-th ORF and j-th codon.

• Format phi.Obs:
  A named vector A of observed expression values and possibly with measurement errors. 
  e.g. A[i] is the observed phi value of i-th ORF.

• Format y:
  A named list A contains amino acids. Each element of the list A[[i]] is a matrix where ORFs 
  are in row and synonymous codons are in column. The element of the matrix contains codon counts. 
  e.g. A[[i]][j,k] is the count for i-th amino acid, j-th ORF, and k-th synonymous codon.

• Format y.list:
  A named list A contains ORFs. Each element of the list A[[i]] is a named list A[[i]][[j]] contains amino acids. The element of amino acids list is a codon count vector. 
  e.g. A[[i]][[j]][k] is the count for i-th ORF, j-th amino acid, and k-th synonymous codon.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.

References

https://github.com/snoweye/cubfits/

Datasets

Datasets for Demonstrations

Description

Examples of toy data to test and demonstrate cubfits.
Datasets

Usage

```r
b.Init
ex.test
ex.train
```

Format

All are in list formats.

Details

**b.Init** contains two sets (roc and rocnse) of initial coefficients including mutation and selection parameters for 3 amino acids 'A', 'C', and 'D' in matrix format. Both sets are in `b` format.

**ex.train** contains a training set of 100 sequences including 3 `reu13.df` (codon counts in `reu13` data frame format divided by amino acids), 3 `y` (codon counts in simplified data frame format divided by amino acids), 3 `n` (total amino acid counts in vector format divided by amino acids), and **phi.Obs** (observed phi values in vector format).

**ex.test** contains a testing set of the other 100 sequences in the same format of **ex.train**.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.

References

```r
https://github.com/snoweye/cubfits/
```

See Also

```r
init.function(), cubfits(), cubpred(), and cubappr().
```

Examples

```r
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

str(b.Init)
str(ex.test)
str(ex.train)

## End(Not run)
```
Estimate Phi

Initialization of Phi (Generic)

Description

This generic function estimates Phi (expression value) either by posterior mean (PM) or by maximum likelihood estimator (MLE) depending on options set by `init.function()`.

Usage

```r
estimatePhi(fitlist, reu13.list, y.list, n.list,
E.Phi = .CF.OP$E.Phi, lower.optim = .CF.OP$lower.optim,
upper.optim = .CF.OP$upper.optim,
lower.integrate = .CF.OP$lower.integrate,
upper.integrate = .CF.OP$upper.integrate, control = list())
```

Arguments

- `fitlist`: an object of format `b`.
- `reu13.list`: an object of format `reu13.list`.
- `y.list`: an object of format `y.list`.
- `n.list`: an object of format `n.list`.
- `E.Phi`: potential expected value of Phi.
- `lower.optim`: lower bound to `optim()`.
- `upper.optim`: upper bound to `optim()`.
- `lower.integrate`: lower bound to `integrate()`.
- `upper.integrate`: upper bound to `integrate()`.
- `control`: control options to `optim()`.

Details

`estimatePhi()` is a generic function first initialized by `init.function()`, then it estimates Phi accordingly. By default, `.CF.CT$init.Phi` sets the method PM for the posterior mean. PM uses a flat prior and `integrate()` to estimate Phi. While, MLE uses `optim()` to estimate Phi which may have boundary solutions for some sequences.

Value

Estimated Phi for every sequence is returned.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.
References

https://github.com/snoweye/cubfits/

See Also

init.function() and fitMultinom().

Examples

```r
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))
set.seed(1234)

# Convert data.
reu13.list <- convert.reu13.df.to.list(ex.test$reu13.df)
y.list <- convert.y.to.list(ex.test$y)
n.list <- convert.n.to.list(ex.test$n)

# Get phi.pred.Init
init.function(model = "roc")
fitlist <- fitMultinom(ex.train$reu13.df, ex.train$phi.Obs, ex.train$y, ex.train$n)
phi.pred.Init <- estimatePhi(fitlist, reu13.list, y.list, n.list,
E.Phi = median(ex.test$phi.Obs),
lower.optim = min(ex.test$phi.Obs) * 0.9,
upper.optim = max(ex.test$phi.Obs) * 1.1)

## End(Not run)
```

Description

This generic function estimates \( b \) (mutation \( \log(\mu) \)) and selection \( \Delta_t \) parameters) depending on options set by \( \text{init.function()}. \)

Usage

```r
fitMultinom(reu13.df, phi, y, n, phi.new = NULL, coefstart = NULL)
```

Arguments

- `phi`: an object of format `phi.Obs`.
- `y`: an object of format `y`.
- `n`: an object of format `n`.
- `phi.new`: an object of format `phi.Obs` for MCMC only.
- `coefstart`: initial value for \( b \) (mutation \( \log(\mu) \)) and selection \( \Delta_t \) parameters) only used in vglm().
Details

fitMultinom() fits a multinomial logistic regression via vector generalized linear model fitting, vglm(). By default, for each amino acids, the last codon (order by characters) is assumed as a based line, and other codons are compared to the based line relatively.

In MCMC, phi.new are new proposed expression values and used to propose new b. The coefstart is used to avoid randomization of estimating b in vglm(), and speed up computation.

Value

A list of format b is returned which are modified from the returns of vglm(). Mainly, it includes b$coefficient (parameters in vector), b$coef.mat (parameters in matrix), and b$R (covariance matrix of parameters, *R* matrix in QR decomposition).

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.

References

https://github.com/snoweye/cubfits/


See Also

init.function() and estimatePhi().

Examples

```r
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))
set.seed(1234)

# Convert data.
reu13.list <- convert.reu13.df.to.list(ex.test$reu13.df)
y.list <- convert.y.to.list(ex.test$y)
n.list <- convert.n.to.list(ex.test$n)

# Get phi.pred.Init
init.function(model = "roc")
fitlist <- fitMultinom(ex.train$reu13.df, ex.train$phi.Obs, ex.train$y, ex.train$n)
phi.pred.Init <- estimatePhi(fitlist, reu13.list, y.list, n.list,
E.Phi = median(ex.test$phi.Obs),
lower.optim = min(ex.test$phi.Obs) * 0.9,
upper.optim = max(ex.test$phi.Obs) * 1.1)

## End(Not run)
```
Generating Utility

Description

These utility functions generate and summarize sequence strings into several useful formats such as `reu13.df`, `y`, and `n`, etc.

Usage

```r
# Generating data frame
gen.reu13.df(seq.string, phi.df = NULL, aa.names = .CF.GV$amino.acid,
             split.S = TRUE, drop.X = TRUE, drop.MW = TRUE,
             drop.1st.codon = TRUE)

gen.y(seq.string, aa.names = .CF.GV$amino.acid,
       split.S = TRUE, drop.X = TRUE, drop.MW = TRUE)

gen.n(seq.string, aa.names = .CF.GV$amino.acid,
       split.S = TRUE, drop.X = TRUE, drop.MW = TRUE)

gen.reu13.list(seq.string, aa.names = .CF.GV$amino.acid,
                split.S = TRUE, drop.X = TRUE, drop.MW = TRUE,
                drop.1st.codon = TRUE)

gen.phi.Obs(phi.df)

gen.scuo(seq.string, aa.names = .CF.GV$amino.acid,
          split.S = TRUE, drop.X = TRUE, drop.MW = TRUE)
```

Arguments

- `seq.string`: a list of sequence strings.
- `phi.df`: a `phi.df` object returned from `read.phi.df()`.
- `aa.names`: a vector contains amino acid names for analysis.
- `split.S`: split amino acid 'S' if any.
- `drop.X`: drop amino acid 'X' if any.
- `drop.MW`: drop amino acid 'M' and 'W' if any.
- `drop.1st.codon`: if drop the first codon.

Details

These functions mainly take inputs of sequence strings `seq.string` or `phi.df` and turn them into corresponding format.

Value

The outputs are data structure in corresponding formats. See `AllDataFormats` for details.
Author(s)
Wei-Chen Chen <wccsnow@gmail.com>.

References
https://github.com/snoweye/cubfits/

See Also
AllDataFormats, read.seq(), read.phi.df(), and convert.seq.data.to.string().

Examples
```
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

seq.data <- read.seq(get.expath("seq_200.fasta"))
phi.df <- read.phi.df(get.expath("phi_200.tsv"))
aa.names <- c("A", "C", "D")

# Read in from FASTA file.
seq.string <- convert.seq.data.to.string(seq.data)
reu13.df <- gen.reu13.df(seq.string, phi.df, aa.names)
reu13.list.new <- gen.reu13.list(seq.string, phi.df, aa.names)
y <- gen.y(seq.string, aa.names)
n <- gen.n(seq.string, aa.names)
scuo <- gen.scuo(seq.string, aa.names)

# Convert to list format.
reu13.list <- convert.reu13.df.to.list(reu13.df)
y.list <- convert.y.to.list(y)
n.list <- convert.n.to.list(n)

## End(Not run)
```

Initial Generic Functions

**Initial Generic Functions of Codon Usage Bias Fits**

Description
Initial generic functions for model fitting/approximation/prediction of **cubfits**.

Usage
```
init.function(model = .CF.CT$model[1],
type.p = .CF.CT$type.p[1],
type.Phi = .CF.CT$type.Phi[1],
model.Phi = .CF.CT$model.Phi[1],
```
Initial Generic Functions

init.Phi = .CF.CT$init.Phi[1],
init.fit = .CF.CT$init.fit[1],
parallel = .CF.CT$parallel[1],
adaptive = .CF.CT$adaptive[1])

Arguments

- **model**: main fitted model.
- **type.p**: proposal method for hyper-parameters.
- **type.Phi**: proposal method for Phi (true expression values).
- **model.Phi**: prior of Phi.
- **init.Phi**: initial methods for Phi.
- **init.fit**: how is coefficient initialized in vglm() of VGAM.
- **parallel**: parallel functions.
- **adaptive**: method for adaptive MCMC.

Details

This function mainly takes the options, find the according generic functions, and assign those functions to .cubfitsEnv. Those generic functions can be executed accordingly later within functions for MCMC or multinomial logistic regression such as cubfits(), cubappr(), and cubpred(). By default, those options are provided by .CF.CT which also leaves rooms for extensions of more complicated models and further optimizations.

It is supposed to call this function before running any MCMC or multinomial logistic regression. This function may affect cubfits(), cubpred(), cubappr(), estimatePhi(), and fitMultinom().

- **model** is the main fitting model, currently only roc is fully supported.
- **type.p** is for proposing hyper-parameters in Gibbs sampler. Currently, lognormal_fix is suggested where mean 1 is fixed for log normal distribution. Conjugated prior and flat prior exist and are easily available in this step.
- **type.Phi** is for proposing Phi (expression values) in the random walk chain updates. Only, RW_Norm is supported. Usually, the acceptance ratio can be adapted within 25% and 50% controlled by .CF.AC if adaptive = simple.
- **model.Phi** is for the distribution of Phi. Typically, log normal distribution lognormal is assumed.
- **init.Phi** is a way to initial Phi. Posterior mean PM is recommended which avoid boundary values.
- **init.fit** is a way of initial coefficients to fit mutation and selection coefficients (log \( \mu \) and \( \Delta t \) or \( \omega \)) in vglm(). Option current means the b (log(mu) and Delta.t) of current MCMC iteration is the initial values, while random means vglm() provides the initial values.
- **parallel** is a way of parallel methods to speed up code. lapply means lapply() is used and no parallel; mclapply means mclapply() of parallel is used and good for shared memory machines; task.pull means task.pull() of pbdMPI is used and good for heterogeneous machines; pbdLapply means pbdLapply() of pbdMPI is used and good for homogeneous machines. Among those, task.pull is tested thoroughly and is the most reliable and efficient method.
adaptive is a way for adaptive MCMC that propose better mixing distributions for random walks of Phi. The simple method is suggested and only the proposal distribution of Phi (type.Phi = RW_Norm) is adjusted gradually.

Value
Return an invisible object which is a list contain all generic functions according to the input options. All functions are also assigned in the .cubfitsEnv for later evaluations called by MCMC or multinomial logistic regression.

Note
Note that all options are taken default values from the global control object .CF.CT, so one can utilize/alter the object’s values to adjust those affected functions.
Note that phi.Obs should be scaled to mean 1 before applying to MCMC.

Author(s)
Wei-Chen Chen <wccsnow@gmail.com>.

References
https://github.com/snoweye/cubfits/

See Also
.CF.CT, .CF.CT, cubfits(), cubpred(), and cubappr().

Examples
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))
set.seed(1234)

# Convert data.
reu13.list <- convert.reu13.df.to.list(ex.test$reu13.df)
y.list <- convert.y.to.list(ex.test$y)
n.list <- convert.n.to.list(ex.test$n)

# Get phi.pred.Init
init.function(model = "roc")
fitlist <- fitMultinom(ex.train$reu13.df, ex.train$phi.Obs, ex.train$y, ex.train$n)
phi.pred.Init <- estimatePhi(fitlist, reu13.list, y.list, n.list,
E.Phi = median(ex.test$phi.Obs),
lower.optim = min(ex.test$phi.Obs) * 0.9,
upper.optim = max(ex.test$phi.Obs) * 1.1)

## End(Not run)
Description

These utility functions read and write data of FASTA and phi.df formats.

Usage

\[
\begin{align*}
\text{read.seq}(\text{file.name, forceDNAtolower = FALSE, convertDNAtoupper = TRUE}) \\
\text{write.seq}(\text{seq.data, file.name}) \\
\text{read.phi.df}(\text{file.name, header = TRUE, sep = \\
"\t", quote = "")} \\
\text{write.phi.df}(\text{phi.df, file.name}) \\
\text{get.expath}(\text{file.name, path.root = \\
"./ex_data/", pkg = "cubfits"})
\end{align*}
\]

Arguments

- **file.name**: a file name to read or write.
- **forceDNAtolower**: an option passed to \text{read.fasta}() of \textit{seqinr} package.
- **convertDNAtoupper**: force everything in upper case.
- **header**: an option passed to \text{read.table}().
- **sep**: an option passed to \text{read.table}().
- **quote**: an option passed to \text{read.table}().
- **seq.data**: a \textit{seq.data} object.
- **phi.df**: a \textit{phi.df} object.
- **path.root**: root path for the file name relatively to the pkg.
- **pkg**: package name for the path of root.

Details

- \text{read.seq}() and \text{write.seq}() typically read and write FASTA files (DNA ORFs or sequences).
- \text{read.phi.df}() and \text{write.phi.df}() typically read and write phi.df files (expression values of ORFs or sequences).
- \text{get.expath}() is only for demonstration returning a full path to the file.

Value

- \text{read.seq}() returns an object of \textit{seq.data} format which can be converted to \textit{seq.string} format later via \text{convert.seq.data.to.string}().
- \text{read.phi.df}() returns an object of \textit{phi.df} format which contains expression values.
Mixed Normal Optimization

Author(s)
Wei-Chen Chen <wccsnow@gmail.com>.

References
https://github.com/snoweye/cubfits/

See Also
convert.seq.data.to.string().

Examples
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

seq.data <- read.seq(get.expath("seq_200.fasta"))
phi.df <- read.phi.df(get.expath("phi_200.tsv"))
aa.names <- c("A", "C", "D")

# Read in from FASTA file.
seq.string <- convert.seq.data.to.string(seq.data)

## End(Not run)

Description
Constrained optimization for mixed normal in 1D and typically for 2 components.

Usage
mixnormerr.optim(X, K = 2, param = NULL)
dmixnormerr(x, param)

Arguments
X        a gene expression data matrix of dimension N * R which has N genes and R replicates.
K        number of components to fit.
x        vector of quantiles.
param    parameters of mixnormerr, typically the element param of the mixnormerr.optim() returning object.
Mixed Normal Optimization

Details

The function `mixnormerr.optim()` maximizes likelihood using `constrOptim()` based on the gene expression data $X$ (usually in log scale) for $N$ genes and $R$ replicates (NA is allowed). The likelihood of each gene expression is a $K = 2$ component mixed normal distribution ($\sum_k p_k N(m_k, \sigma_k^2 + \sigma_e^2)$) with measurement errors of the replicates ($N(0, \sigma_e^2)$).

The $\sigma_k^2$ is as the error of random component and the $\sigma_e^2$ is as the error of fixed component. Both are within a mixture model of two normal distributions.

The function `dmixnormerr()` computes the density of the mixed normal distribution.

`param` is a parameter list and contains five elements: $K$ for number of components, $prop$ for proportions, $mu$ for centers of components, $sigma2$ for variance of components, and $sigma2.e$ for variance of measurement errors.

Value

`mixnormerr.optim()` returns a list containing three main elements `param` is the final results (MLEs), `param.start` is the starting parameters, and `optim.ret` is the original returns of `constrOptim()`.

Note

This function is limited for small $K$. An equivalent EM algorithm should be done in a more stable way for large $K$.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.

References

https://github.com/snoweye/cubfits/

See Also

`print.mixnormerr()`, `simu.mixnormerr()`.

Examples

```r
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

### Get individual of phi.Obs.
GM <- apply(yassour[, -1], 1, function(x) exp(mean(log(x[x != 0]))))
phi.Obs.all <- yassour[, -1] / sum(GM) * 15000
phi.Obs.all[phi.Obs.all == 0] <- NA

### Run optimization.
X <- log(as.matrix(phi.Obs.all))
param.init <- list(K = 2, prop = c(0.95, 0.05), mu = c(-0.59, 3.11),
                   sigma2 = c(1.40, 0.59), sigma2.e = 0.03)
ret <- mixnormerr.optim(X, K = 2, param = param.init)
```
print(ret)
## End(Not run)

---

### Description

Plot binning results to visualize the effects of mutation and selection along with expression levels empirically.

### Usage

```r
prop.bin.roc(reu13.df, phi.Obs = NULL, nclass = 20, bin.class = NULL,
             weightedCenters = TRUE, logBins = FALSE)
```

```r
plotbin(ret.bin, ret.model = NULL, main = NULL,
        xlab = "Production Rate (log10)", ylab = "Proportion",
        xlim = NULL, lty = 1, x.log10 = TRUE, stderr = FALSE, ...)
```

### Arguments

- `nclass`: number of binning classes across the range of `phi.Obs`.
- `bin.class`: binning proportion, e.g. `c(0, seq(0.05, 0.95, length = nclass), 1)`.
- `ret.bin`: binning results from `prop.bin.roc()`.
- `weightedCenters`: if centers are weighted.
- `logBins`: if use log scale for bin.
- `ret.model`: model results from `prop.model.roc()`.
- `main`: an option passed to `plot()`.
- `xlab`: an option passed to `plot()`.
- `ylab`: an option passed to `plot()`.
- `xlim`: range of X-axis.
- `lty`: line type if `ret.model` is provided.
- `x.log10`: `log10()` transformation of X-axis.
- `stderr`: plot stand error instead of stand deviation.
- `...`: options passed to `plot()`.
**Details**

The function `plotbin()` plots the binning results `ret.bin` returned from `prop.bin.roc()`. Fitted curves may be added if `ret.model` is provided which can be obtained from `prop.model.roc()`. `plotaddmodel()` can append model later if `ret.model` is not provided to `plotbin()`. Currently, only ROC model is supported. Colors are controlled by `.CF.PT`.

**Value**

A binning plot is drawn.

**Author(s)**

Wei-Chen Chen <wccsnow@gmail.com>.

**References**

https://github.com/snoweye/cubfits/

**See Also**

`plotmodel()` and `prop.model.roc()`.

**Examples**

```r
## Not run:
demo(plotbin, 'cubfits', ask = F, echo = F)
## End(Not run)
```

---

### Plotmodel

**Plot Fitted Models**

**Description**

Plot model results to visualize the effects of mutation and selection along with expression levels. The model can be fitted by MCMC or multinomial logistic regression.

**Usage**

```r
prop.model.roc(b.Init, phi.Obs.lim = c(0.01, 10), phi.Obs.scale = 1, nclass = 40, x.log10 = TRUE)

plotmodel(ret.model, main = NULL, xlab = "Production Rate (log10)", ylab = "Proportion", xlim = NULL, lty = 1, x.log10 = TRUE, ...)

plotaddmodel(ret.model, lty, u.codon = NULL, color = NULL, x.log10 = TRUE)
```
Plotmodel

Arguments

b.Init  a b object.
phi.Obs.lim  range of phi.Obs.
phi.Obs.scale  optional scaling factor.
nclass  number of binning classes across the range of phi.Obs.
x.log10  log10() transformation of X-axis.
ret.model  model results from prop.model.roc().
main  an option passed to plot().
xlab  an option passed to plot().
ylab  an option passed to plot().
xlim  range of X-axis.
lty  line type.
u.codon  unique synonymous codon names.
color  a color vector for unique codon, typically returns of the internal function get.color().
...  options passed to plot().

Details

The function plotmodel() plots the fitted curves obtained from prop.model.roc().
The function plotaddmodel() can append model curves to a binning plot provided unique synonymous codons and colors are given. This function is nearly for an internal call within plotmodel(), but is exported and useful for workflow.
Currently, only ROC model is supported. Colors are controlled by .CF.PT.

Value

A fitted curve plot is drawn.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.

References

https://github.com/snoweye/cubfits/

See Also

plotbin(), prop.bin.roc(), and prop.model.roc().

Examples

## Not run:
demo(plotbin, 'cubfits', ask = F, echo = F)

## End(Not run)
Description

This utility function provides a basic plot of production rates.

Usage

\[
\text{plotprxy}(x, y, x\.ci = \text{NULL}, y\.ci = \text{NULL}, \\
\quad \text{log10}\.x = \text{TRUE}, \text{log10}\.y = \text{TRUE}, \\
\quad \text{add.lm} = \text{TRUE}, \text{add.one.to.one} = \text{TRUE}, \text{weights} = \text{NULL}, \\
\quad \text{add.legend} = \text{TRUE}, \\
\quad \text{xlim} = \text{NULL}, \text{ylim} = \text{NULL}, \\
\quad xlab = "Predicted Production Rate (log10)", \\
\quad ylab = "Observed Production Rate (log10)", \\
\quad \text{main} = \text{NULL})
\]

Arguments

- **x**: expression values.
- **y**: expression values, of the same length of x.
- **x\.ci**: confidence interval of x, of dimension \text{length}(x) \times 2, for outliers labeling.
- **y\.ci**: confidence interval of y, of dimension \text{length}(y) \times 2, for outliers labeling.
- **log10\.x**: \text{log10}() and mean transformation of x axis.
- **log10\.y**: \text{log10}() and mean transformation of y axis.
- **add.lm**: if add \text{lm}() fit.
- **add.one.to.one**: if add one-to-one line.
- **weights**: weights to \text{lm}().
- **add.legend**: if add default legend.
- **xlim**: limits of x-axis.
- **ylim**: limits of y-axis.
- **xlab**: an option passed to \text{plot}().
- **ylab**: an option passed to \text{plot}().
- **main**: an option passed to \text{plot}().

Details

As the usual X-Y plot where x and y are expression values.

If \text{add.lm} = \text{TRUE} and \text{weights} are given, then both ordinary and weighted least squares results will be plotted.
Posterior Results of Yassour2009

Value

A scatter plot with a fitted lm() line and R squared value.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.

References

https://github.com/snoweye/cubfits/

See Also

plotbin() and plotmodel().

Examples

```r
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

y.scuo <- convert.y.to.scuo(ex.train$y)
SCUO <- calc_scuo_values(y.scuo)$SCUO
plotprxy(ex.train$phi.Obs, SCUO)
## End(Not run)
```

Posterior Results of Yassour2009

Posterior Results of Yassour 2009 Yeast Experiment Dataset

Description

Output summarized from MCMC posterior results analyzing Yassour 2009 data.

Usage

yassour.PM.fits
yassour.PM.appr
yassour.info

Format

These are list’s containing several posterior means: E.Phi for expected expression, b.InitList.roc for parameters, AA.prob for proportion of amino acids, sigmaW for standard error of measure errors, and gene.length for gene length.
yassour.PM.fits and yassour.PM.appr are the MCMC output of with/without observed expression, respectively. Both contain posterior means of expected expressions and coefficient parameters: E.Phi and b.InitList.roc are scaled results such that each MCMC iteration has mean 1 at E.Phi. yassour.info contains sequences information (Yeast): AA.prob and gene.length are summarized from corresponding genes in the analysis.

Note that some of genes may not have good quality of expression or sequence information, so those genes are dropped from yassour dataset.

References

https://github.com/snoweye/cubfits/

See Also

yassour

Examples

```r
## Not run:
str(yassour.PM.fits)
str(yassour.PM.appr)
str(yassour.PM.info)
## End(Not run)
```

Description

A Class `mixnormerr` is declared in `cubfits`, and this is the function to print and summary objects.

Usage

```r
## S3 method for class 'mixnormerr'
print(x, digits = max(4, getOption("digits") - 3), ...)
```

Arguments

- `x` an object with the class attributes.
- `digits` for printing out numbers.
- `...` other possible options.

Details

This is an useful function for summarizing and debugging.
Randomize SCUO Index

Value
The results will cat or print on the STDOUT by default.

Author(s)
Wei-Chen Chen <wccsnow@gmail.com>.

References
https://github.com/snoweye/cubfits/

See Also
mixnormerr.optim().

Examples
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

### Get individual of phi.Obs.
GM <- apply(yassour[, -1], 1, function(x) exp(mean(log(x[x != 0]))))
phi.Obs.all <- yassour[, -1] / sum(GM) * 15000
phi.Obs.all[phi.Obs.all == 0] <- NA

### Run optimization.
X <- log(as.matrix(phi.Obs.all))
param.init <- list(K = 2, prop = c(0.95, 0.05), mu = c(-0.59, 3.11),
                   sigma2 = c(1.40, 0.59), sigma2.e = 0.03)
ret <- mixnormerr.optim(X, K = 2, param = param.init)
print(ret)

## End(Not run)
Randomize SCUO Index

Arguments

SCUO  SCUO index returned from \texttt{calc\_scuo\_values()}.
phi.Obs  optional object of format \texttt{phi.Obs}.
meanlog  mean of log normal distribution.
sdlog  std of log normal distribution.

Details

This function takes SCUO indices (outputs of \texttt{calc\_scuo\_values()}) computes the rank of them, generates log normal random variables, and replaces SCUO indices by those variables in the same rank orders. Typically, these random variables are used to replace expression values when either no expression is observed or for the purpose of model validation.

If \texttt{phi.Obs} is provided, the mean and std of log(\texttt{phi.Obs}) are used for log normal random variables. Otherwise, \texttt{meanlog} and \texttt{sdlog} are used.

The default \texttt{meanlog} and \texttt{sdlog} was estimated from \texttt{yassour} dataset.

Value

A vector of log normal random variables is returned.

Author(s)

Wei-Chen Chen \texttt{<wccsnow@gmail.com>}.

References

\url{https://github.com/snoweye/cubfits/}

See Also

\texttt{calc\_scuo\_values()}, \texttt{yassour}.

Examples

```r
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

### example dataset.
y.scuo <- convert.y.to.scuo(ex.train$y)
SCUO <- calc_scuo_values(y.scuo)$SCUO
plotprxy(ex.train$phi.Obs, SCUO)

### yassour dataset.
GM <- apply(yassour[, -1], 1, function(x) exp(mean(log(x[x != 0]))))
phi.Obs <- GM / sum(GM) * 15000
mean(log(phi.Obs))
sd(log(phi.Obs))
ret <- scuo.random(SCUO, meanlog = -0.441473, sdlog = 1.393285)
plotprxy(ret, SCUO)
```
Rearrangement Utility  

Rearrange Data Structure by ORF Names

Description

These utility functions rearrange data in the order of ORF names.

Usage

rearrange.reu13.df(reu13.df)
rearrange.y(y)
rearrange.n(n)
rearrange.phi.Obs(phi.Obs)

Arguments

reu13.df  a list of reu13.df data frames divided by amino acids.
y  a list of y data frames divided by amino acids.
n  a list of n vectors divided by amino acids.
phi.Obs  a vector of phi.Obs format.

Details

These utility functions take inputs and return ordered outputs. It is necessary to rearrange data in a right order of ORF names which avoids subsetting data frame within MCMC and improve performance.

Value

The outputs are in the same format of inputs except the order of data is sorted by ORF names.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.

References

https://github.com/snoweye/cubfits/

See Also

AllDataFormats, convert.n.to.list(), convert.reu13.df.to.list(), and convert.y.to.list().
Examples

```r
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

reu13.df <- rearrange.reu13.df(ex.train$reu13.df)
y <- rearrange.y(ex.train$y)
n <- rearrange.n(ex.train$n)
phi.Obs <- rearrange.phi.Obs(ex.train$phi.Obs)

## End(Not run)
```

SCUO Index

Function for Synonymous Codon Usage Order (SCUO) Index

Description

Calculate the Synonymous Codon Usage Order (SCUO) index for each gene. Used as a substitute for expression in cases of without expression measurements.

Usage

```r
calc_scuo_values(codon.counts)
```

Arguments

- **codon.counts**: an object of format `scuo`.

Details

This function computes SCUO index for each gene. Typically, this method is completely based on entropy and information theory to estimate expression values of sequences according to their codon information.

Value

SCUO indices are returned.

Author(s)

Drew Schmidt.

References

[https://www.tandfonline.com/doi/abs/10.1080/03081070500502967](https://www.tandfonline.com/doi/abs/10.1080/03081070500502967)

Selection on Codon Usage

See Also

scuo.random(), calc_cai_values(), calc_scu_values().

Examples

## Not run:
suppressMessages(library(cubfits, quietly = TRUE))

y.scuo <- convert.y.to.scuo(ex.train$y)
SCUO <- calc_scuo_values(y.scuo)$SCUO
plotprxy(ex.train$phi.Obs, SCUO, ylab = "SCUO (log10)"
## End(Not run)

Selection on Codon Usage

Function for Selection on Codon Usage (SCU)

Description

Calculate the average translational selection per transcript include mSCU and SCU (if gene expression is provided) for each gene.

Usage

calc_scu_values(b, y.list, phi.Obs = NULL)

Arguments

b an object of format b.
y.list an object of format y.list.
phi.Obs an object of format phi.Obs, for SCU only.

Details

This function computes SCU and mSCU for each gene. Typically, this method is completely based on estimated parameters of mutation and selection such as outputs of MCMC or fitMultinom().

Value

A list with two named elements SCU and mSCU are returned.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.
Simulation Tool

References


See Also

calc_scuo_values(), calc_cai_values().

Examples

```r
## Not run:
library(cubfits, quietly = TRUE)

b <- b.Init$roc
phi.Obs <- ex.train$phi.Obs
y <- ex.train$y
y.list <- convert.y.to.list(y)
mSCU <- calc_scu_values(b, y.list, phi.Obs)$mSCU
plot(mSCU, log10(phi.Obs), main = "Expression vs mSCU",
     xlab = "mSCU", ylab = "Expression (log10)")

### Compare with CAI with weights seqinr::cubtab$sc.
library(seqinr, quietly = TRUE)
w <- caitab$sc
names(w) <- codon.low2up(rownames(caitab))
CAI <- calc_cai_values(y, y.list, w = w)$CAI

plot(mSCU, CAI, main = "CAI vs mSCU",
     xlab = "mSCU", ylab = "CAI")

## End(Not run)
```

Simulation Tool

Simulate ORFs and Expression Data

Description

These utility functions generate data for simulation studies including fake ORFs and expression values.

Usage

```r
simu.orf(n, b.Init, phi.Obs = NULL, AA.prob = NULL, orf.length = NULL, orf.names = NULL, model = .CF.CT$model)
simu.phi.Obs(Phi, sigmaW.lim = 1, bias.Phi = 0)
simu.mixnormerr(n, param)
```
Arguments

- **n**: number of ORFs or sequences.
- **b.Init**: parameters of mutation and selection of format `b`.
- **phi.Obs**: an object of format `phi.Obs`.
- **AA.prob**: proportion of amino acids.
- **orf.length**: lengths of ORFs.
- **orf.names**: names of ORFs.
- **model**: model to be simulated.
- **Phi**: expression values (potentially true expression).
- **sigmaW.lim**: std of measurement errors (between Phi and phi.Obs).
- **bias.Phi**: bias (in log scale) for observed phi.
- **param**: as in `dmixnormerr()`

Details

- `simu.orf()` generates ORFs or sequences based on the `b.Init` and `phi.Obs`.
  If `phi.Obs` is omitted, then standard log normal random variables are instead).
  If `AA.prob` is omitted, then uniform proportion is assigned.
  If `orf.length` is omitted, then 10 to 20 codons are randomly assigned.
  If `orf.names` is omitted, then "ORF1" to "ORFn" are assigned.
- `simu.phi.Obs()` generates `phi.Obs` by adding normal random errors to `Phi`, and errors have mean 0 and standard deviation `sigmaW.lim`.
- `simu.mixnormerr()` generates `Phi` according to the `param`, and adds normal random errors to `Phi`.

Value

- `simu.orf()` returns a list of format `seq.data`.
- `simu.phi.Obs()` returns a vector of format `phi.Obs`.
- `simu.mixnormerr()` returns a list contains three vectors of length `n`: one for expected gene expression `Phi`, one for observed gene expression `phi.Obs`, and one for the component id `id.K`.

Author(s)

Wei-Chen Chen <wccsnow@gmail.com>.

References

- [https://github.com/snoweye/cubfits/](https://github.com/snoweye/cubfits/)

See Also

- `read.seq()`, `read.phi.df()`, `write.seq()`, `write.phi.df()`, and `mixnormerr.optim()`.
Examples

```r
## Not run:
suppressMessages(library(cubfits, quietly = TRUE))
set.seed(1234)

# Generate sequences.
da.roc <- simu.orf(length(ex.train$phi.Obs), b.Init$roc,
                   phi.Obs = ex.train$phi.Obs, model = "roc")
names(da.roc) <- names(ex.train$phi.Obs)
write.fasta(da.roc, names(da.roc), "toy_roc.fasta")

## End(Not run)
```

Description

Experiments and data are obtained from Yassour et. al. (2009).

Usage

```r
yassour
```

Format

A `data.frame` contains 6303 rows and 5 columns: ORF is for gene names in character, and YPD0.1, YPD0.2, YPD15.1, and YPD15.2 are gene expressions in positive double corresponding to 4 controlled Yeast experiments.

Details

The original data are available as the URL of the section of Source next. As the section of Examples next, data are selected from SD3.xls and reordered by ORF.

For further analysis, the Examples section also provides how to convert them to phi.Obs values either in geometric means or individually.

Source

https://www.pnas.org/content/early/2009/02/10/0812841106

References


Examples

```r
## Not run:
### SD3.xls is available from the URL provided in the References.
da <- read.table("SD3.xls", header = TRUE, sep = "\t", quote = "\",
                     stringsAsFactors = FALSE)

### Select ORF, YPD0.1, YPD0.2, YPD15.1, YPD15.2.
da <- da[, c(1, 8, 9, 10, 11)]
colnames(da) <- c("ORF", "YPD0.1", "YPD0.2", "YPD15.1", "YPD15.2")

### Drop inappropriate values (NaN, NA, Inf, -Inf, and 0).
tmp <- da[, 2:5]
id.tmp <- rowSums(is.finite(as.matrix(tmp)) & tmp != 0) >= 3
tmp <- da[id.tmp, 1:5]
yassour <- tmp[order(tmp$ORF),]  # cubfits::yassour

### Get geometric mean of phi.Obs and scaling similar to Wallace (2013).
GM <- apply(yassour[, -1], 1, function(x) exp(mean(log(x[x != 0])))
phi.Obs <- GM / sum(GM) * 15000

### Get individual of phi.Obs.
GM <- apply(yassour[, -1], 1, function(x) exp(mean(log(x[x != 0])))
phi.Obs.all <- yassour[, -1] / sum(GM) * 15000
phi.Obs.all[phi.Obs.all == 0] <- NA

## End(Not run)
```
Index

* cedric
  Cedric Convergence Utilities, 6
  Cedric IO Utilities, 7
  Cedric Plot Utilities, 8

* dataformats
  Data Formats, 23

* datasets
  Controls, 11
  Datasets, 24
  Posterior Results of Yassour2009, 40
  Yassour2009, 49

* main function
  CUB Model Approximation, 16
  CUB Model Fits, 18
  CUB Model Prediction, 20

* package
  cubfits-package, 2

* plotting
  Plotbin, 36
  Plotmodel, 37
  Plotprxy, 39

* summary
  Print, 41

* tool
  Codon Adaptation Index, 10
  Estimate Phi, 26
  Fit Multinomial, 27
  Initial Generic Functions, 30
  Randomize SCUO Index, 42
  SCUO Index, 45
  Selection on Codon Usage, 46
  Simulation Tool, 47

* utility
  Asymmetric Laplace Distribution, 4
  Coverting Utility, 14
  Generating Utility, 29
  Input and Output Utility, 33
  Mixed Normal Optimization, 34
  Rearrangement Utility, 44
  .CF.AC, 31
  .CF.AC (Controls), 11
  .CF.CONF (Controls), 11
  .CF.CT, 31, 32
  .CF.CT (Controls), 11
  .CF.DP, 17, 19, 22
  .CF.DP (Controls), 11
  .CF.GV (Controls), 11
  .CF.OP (Controls), 11
  .CF.PARAM (Controls), 11
  .CF.PT, 37, 38
  .CF.PT (Controls), 11
  .CO.CT (Controls), 11
  .cubfitsEnv, 31, 32
  .cubfitsEnv (Controls), 11

  AllDataFormats, 16, 29, 30, 44
  AllDataFormats (Data Formats), 23
  asl.optim (Asymmetric Laplace Distribution), 4
  Asymmetric Laplace Distribution, 4
  b, 15, 17, 19, 21, 22, 25–28, 31, 38, 46, 48
  b (Data Formats), 23
  b.Init (Datasets), 24
  bVec, 15
  bVec (Data Formats), 23
  calc_cai_values, 46, 47
  calc_cai_values (Codon Adaptation Index), 10
  calc_scu_values, 10, 46
  calc_scu_values (Selection on Codon Usage), 46
  calc_scuo_values, 10, 43, 47
  calc_scuo_values (SCUO Index), 45
  Cedric Convergence Utilities, 6
  Cedric IO Utilities, 7
  Cedric Plot Utilities, 8
Codon Adaptation Index, 10
codon.low2up (Coverting Utility), 14
codon.up2low (Coverting Utility), 14
Controls, 11
convert.b.to.bVec (Coverting Utility), 14
convert.bVec.to.b (Coverting Utility), 14
convert.n.to.list, 44
convert.y.to.list (Coverting Utility), 14
correct.seq.data.to.string, 30, 33, 34
convert.seq.data.to.string (Coverting Utility), 14
convert.y.to.scuo (Coverting Utility), 14
Converting Utility, 14
CUB Model Approximation, 16
CUB Model Fits, 18
CUB Model Prediction, 20
cubappr, 3, 14, 20, 22, 25, 31, 32
cubappr (CUB Model Approximation), 16
cubfits, 3, 14, 18, 22, 25, 31, 32
cubfits (CUB Model Fits), 18
cubfits-package, 2
cubmultichain (Cedric Convergence Utilities), 6
cubpred, 3, 14, 18, 20, 25, 31, 32
cubpred (CUB Model Prediction), 20
cubsinglechain (Cedric Convergence Utilities), 6
dasl (Asymmetric Laplace Distribution), 4
dasla (Asymmetric Laplace Distribution), 4
Data Formats, 23
DataConverting, 18, 20, 22
DataConverting (Converting Utility), 14
DataGenerating (Generating Utility), 29
DataIO, 18, 20, 22
DataIO (Input and Output Utility), 33
Datasets, 24
dmixnormerr, 48
dmixnormerr (Mixed Normal Optimization), 34
dna.low2up (Coverting Utility), 14
dna.up2low (Coverting Utility), 14
Estimate Phi, 26
estimatePhi, 28, 31
estimatePhi (Estimate Phi), 26
ex.test (Datasets), 24
ex.train (Datasets), 24
Fit Multinomial, 27
fitMultinom, 27, 31, 46
fitMultinom (Fit Multinomial), 27
gen.n (Generating Utility), 29
gen.phi.Obs (Generating Utility), 29
gen.reu13.df (Generating Utility), 29
gen.reu13.list (Generating Utility), 29
gen.scuo (Generating Utility), 29
gen.y (Generating Utility), 29
Generating Utility, 29
get.expath (Input and Output Utility), 33
init.function, 3, 12, 14, 25–28
init.function (Initial Generic Functions), 30
Initial Generic Functions, 30
Input and Output Utility, 33
isConverged (Cedric Convergence Utilities), 6
Mixed Normal Optimization, 34
mixnormerr.optim, 14, 42, 48
mixnormerr.optim (Mixed Normal Optimization), 34
n, 15, 17, 19, 21, 25, 27, 29, 44
n (Data Formats), 23
n.list, 26
normalizeDataSet (Cedric IO Utilities), 7
pasl (Asymmetric Laplace Distribution), 4
pasla (Asymmetric Laplace Distribution), 4
phi.df, 29, 33
phi.df (Data Formats), 23
phi.Obs, 17, 19, 21, 25, 27, 36, 43, 44, 46, 48
phi.Obs (Data Formats), 23
plotaddmodel, 37
plotaddmodel (Plotmodel), 37
Plotbin, 36
plotbin, 38, 40
plotbin (Plotbin), 36
plotCUB (Cedric Plot Utilities), 8
plotExpectedPhiTrace (Cedric Plot Utilities), 8
Plotmodel, 37
plotmodel, 37, 40
plotmodel (Plotmodel), 37
Plotprxy, 39
plotprxy (Plotprxy), 39
plotPTraces (Cedric Plot Utilities), 8
plotTraces (Cedric Plot Utilities), 8
Posterior Results of Yassour2009, 40
Print, 41
print.mixnormerr, 35
print.mixnormerr (Print), 41
prop.bin.roc, 36, 38
prop.bin.roc (Plotbin), 36
prop.model.roc, 36–38
prop.model.roc (Plotmodel), 37
qasl (Asymmetric Laplace Distribution), 4
qasla (Asymmetric Laplace Distribution), 4
Randomize SCUO Index, 42
rasl (Asymmetric Laplace Distribution), 4
rasla (Asymmetric Laplace Distribution), 4
read.phi.df, 29, 30, 48
read.phi.df (Input and Output Utility), 33
read.seq, 16, 30, 48
read.seq (Input and Output Utility), 33
readGenome (Cedric IO Utilities), 7
rearrange.n, 16
rearrange.n (Rearrangement Utility), 44
rearrange.phi.Obs (Rearrangement Utility), 44
rearrange.reu13.df, 16
rearrange.reu13.df (Rearrangement Utility), 44
rearrange.y, 16
rearrange.y (Rearrangement Utility), 44
Rearrangement Utility, 44
reu13.df, 15, 17, 19, 21, 25, 27, 29, 36, 44
reu13.df (Data Formats), 23
reu13.list, 26
reu13.list (Data Formats), 23
scuo, 15, 45
scuo (Data Formats), 23
SCUO Index, 45
scuo.random, 46
scuo.random (Randomize SCUO Index), 42
Selection on Codon Usage, 46
seq.data, 15, 33, 48
seq.data (Data Formats), 23
seq.string, 15, 29, 33
seq.string (Data Formats), 23
simu.mixnormerr, 35
simu.mixnormerr (Simulation Tool), 47
simu.orf (Simulation Tool), 47
simu.phi.Obs (Simulation Tool), 47
Simulation Tool, 47
write.phi.df, 48
write.phi.df (Input and Output Utility), 33
write.seq, 48
write.seq (Input and Output Utility), 33
y, 10, 15, 17, 19, 21, 25, 27, 29, 44
y (Data Formats), 23
y.list, 10, 26, 46
yassour, 41
yassour (Yassour2009), 49
yassour.info (Posterior Results of Yassour2009), 40
yassour.PM.appr (Posterior Results of Yassour2009), 40
yassour.PM.fits (Posterior Results of Yassour2009), 40
Yassour2009, 49