# Package ‘Cyclops’

June 17, 2021

<table>
<thead>
<tr>
<th>Type</th>
<th>Package</th>
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<tbody>
<tr>
<td>Title</td>
<td>Cyclic Coordinate Descent for Logistic, Poisson and Survival Analysis</td>
</tr>
<tr>
<td>Version</td>
<td>3.1.2</td>
</tr>
<tr>
<td>Description</td>
<td>This model fitting tool incorporates cyclic coordinate descent and majorization-minimization approaches to fit a variety of regression models found in large-scale observational healthcare data. Implementations focus on computational optimization and fine-scale parallelization to yield efficient inference in massive datasets. Please see: Suchard, Simpson, Zorych, Ryan and Madigan (2013) <a href="">doi:10.1145/2414416.2414791</a>.</td>
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<td>License</td>
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<td>LazyData</td>
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<td><a href="https://github.com/ohdsi/cyclops">https://github.com/ohdsi/cyclops</a></td>
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<tr>
<td>BugReports</td>
<td><a href="https://github.com/ohdsi/cyclops/issues">https://github.com/ohdsi/cyclops/issues</a></td>
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<tr>
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<td>R (&gt;= 3.1.0)</td>
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<tr>
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<tr>
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<tr>
<td>Author</td>
<td>Marc A. Suchard [aut, cre], Martijn J. Schuemie [aut], Trevor R. Shaddox [aut], Yuxi Tian [aut], Jianxiao Yang [aut], Eric Kawaguchi [aut], Sushil Mittal [ctb], Observational Health Data Sciences and Informatics [cph], Marcus Geelnard [cph, ctb] (provided the TinyThread library), Rutgers University [cph, ctb] (provided the HParSearch routine), R Development Core Team [cph, ctb] (provided the ZeroIn routine)</td>
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**coef.cyclopsFit**

Extract model coefficients

**Description**

`coef.cyclopsFit` extracts model coefficients from an Cyclops model fit object.

**Usage**

```r
## S3 method for class 'cyclopsFit'
coef(object, rescale = FALSE, ignoreConvergence = FALSE, ...)
```

**Arguments**

- `object`: Cyclops model fit object
- `rescale`: Boolean: rescale coefficients for unnormalized covariate values
- `ignoreConvergence`: Boolean: return coefficients even if fit object did not converge
- `...`: Other arguments

**Value**

Named numeric vector of model coefficients.

---

**confint.cyclopsFit**  
Confidence intervals for Cyclops model parameters

**Description**

`confint.cyclopsFit` profiles the data likelihood to construct confidence intervals of arbitrary level. Usually it only makes sense to do this for variables that have not been regularized.

**Usage**

```r
## S3 method for class 'cyclopsFit'
confint(
  object,
  parm,
  level = 0.95,
  overrideNoRegularization = FALSE,
  includePenalty = TRUE,
  rescale = FALSE,
  ...
)
```
Arguments

- **object**: A fitted Cyclops model object
- **parm**: A specification of which parameters require confidence intervals, either a vector of numbers of covariateId names
- **level**: Numeric: confidence level required
- **overrideNoRegularization**: Logical: Enable confidence interval estimation for regularized parameters
- **includePenalty**: Logical: Include regularized covariate penalty in profile
- **rescale**: Boolean: rescale coefficients for unnormalized covariate values
- **...**: Additional argument(s) for methods

Value

A matrix with columns reporting lower and upper confidence limits for each parameter. These columns are labelled as (1-level)/2 and 1 - (1 - level)/2 in percent (by default 2.5 percent and 97.5 percent)

Examples

```r
#Generate some simulated data:
sim <- simulateCyclopsData(nstrata = 1, nrows = 1000, ncovars = 2, eCovarsPerRow = 0.5,
                            model = "poisson")
cyclopsData <- convertToCyclopsData(sim$outcomes, sim$covariates, modelType = "pr",
                                     addIntercept = TRUE)

#Define the prior and control objects to use cross-validation for finding the
#optimal hyperparameter:
prior <- createPrior("laplace", exclude = 0, useCrossValidation = TRUE)
control <- createControl(cvType = "auto", noiseLevel = "quiet")

#Fit the model
fit <- fitCyclopsModel(cyclopsData, prior = prior, control = control)

#Find out what the optimal hyperparameter was:
getHyperParameter(fit)

#Extract the current log-likelihood, and coefficients
logLik(fit)
coef(fit)

#We can only retrieve the confidence interval for unregularized coefficients:
confint(fit, c(0))
```
**convertToCyclopsData**

Convert data from two data frames or ffdf objects into a CyclopsData object

**Description**

`convertToCyclopsData` loads data from two data frames or ffdf objects, and inserts it into a Cyclops data object.

**Usage**

```r
convertToCyclopsData(
  outcomes,
  covariates,
  modelType = "lr",
  addIntercept = TRUE,
  checkSorting = NULL,
  checkRowIds = TRUE,
  normalize = NULL,
  quiet = FALSE,
  floatingPoint = 64
)
```

## S3 method for class 'data.frame'
```r
classToCyclopsData(
  outcomes,
  covariates,
  modelType = "lr",
  addIntercept = TRUE,
  checkSorting = NULL,
  checkRowIds = TRUE,
  normalize = NULL,
  quiet = FALSE,
  floatingPoint = 64
)
```

## S3 method for class 'tbl_dbi'
```r
classToCyclopsData(
  outcomes,
  covariates,
  modelType = "lr",
  addIntercept = TRUE,
  checkSorting = NULL,
  checkRowIds = TRUE,
  normalize = NULL,
  quiet = FALSE,
  floatingPoint = 64
)
```
Arguments

outcomes A data frame or ffdf object containing the outcomes with predefined columns (see below).
covariates A data frame or ffdf object containing the covariates with predefined columns (see below).
modelType Cyclops model type. Current supported types are "pr", "cpr", "lr", "clr", or "cox"
addIntercept Add an intercept to the model?
checkSorting (DEPRECATED) Check if the data are sorted appropriately, and if not, sort.
checkRowIds Check if all rowIds in the covariates appear in the outcomes.
normalize String: Name of normalization for all non-indicator covariates (possible values: stdev, max, median)
quiet If true, (warning) messages are suppressed.
floatingPoint Specified floating-point representation size (32 or 64)

Details

These columns are expected in the outcome object:

stratumId (integer) (optional) Stratum ID for conditional regression models
rowId (integer) Row ID is used to link multiple covariates (x) to a single outcome (y)
y (real) The outcome variable
time (real) For models that use time (e.g. Poisson or Cox regression) this contains time (e.g. number of days)
weights (real) (optional) Non-negative weights to apply to outcome
censorWeights (real) (optional) Non-negative censoring weights for competing risk model; will be computed if not provided

These columns are expected in the covariates object:

stratumId (integer) (optional) Stratum ID for conditional regression models
rowId (integer) Row ID is used to link multiple covariates (x) to a single outcome (y)
covariateId (integer) A numeric identifier of a covariate
covariateValue (real) The value of the specified covariate

Value

An object of type cyclopsData

Methods (by class)

- data.frame: Convert data from two data.frame
- tbl_dbi: Convert data from two Andromeda tables
Examples

# Convert infert dataset to Cyclops format:
covariates <- data.frame(stratumId = rep(infert$stratum, 2),
rowId = rep(1:nrow(infert), 2),
covariateId = rep(1:2, each = nrow(infert)),
covariateValue = c(infert$spontaneous, infert$induced))

outcomes <- data.frame(stratumId = infert$stratum,
rowId = 1:nrow(infert),
y = infert$case)

# Make sparse:
covariates <- covariates[covariates$covariateValue != 0, ]

# Create Cyclops data object:
cyclopsData <- convertToCyclopsData(outcomes, covariates, modelType = "clr",
                        addIntercept = FALSE)

# Fit model:
fit <- fitCyclopsModel(cyclopsData, prior = createPrior("none"))

<table>
<thead>
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<th>coverage</th>
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</table>

Description

coverage computes the coverage on confidence intervals

Usage

coverage(goldStandard, lowerBounds, upperBounds)

Arguments

goldStandard Numeric vector
lowerBounds Numeric vector. Lower bound of the confidence intervals
upperBounds Numeric vector. Upper bound of the confidence intervals

Value

The proportion of times goldStandard falls between lowerBound and upperBound
**createAutoGridCrossValidationControl**

Create a Cyclops control object that supports multiple hyperparameters.

**Description**

createAutoGridCrossValidationControl creates a Cyclops control object for use with `fitCyclopsModel` that supports multiple hyperparameters through an auto-search in one dimension and a grid-search over the remaining dimensions.

**Usage**

```r
createAutoGridCrossValidationControl(outerGrid, autoPosition = 1, refitAtMaximum = TRUE, cvType = "auto", initialValue = 1, ...
)
```

**Arguments**

- `outerGrid` List or data.frame of grid parameters to explore
- `autoPosition` Vector position for auto-search parameter (concatenated into outerGrid)
- `refitAtMaximum` Logical: re-fit Cyclops object at maximal cross-validation parameters
- `cvType` Must equal "auto"
- `initialValue` Initial value for auto-search parameter
- `...` Additional parameters passed through to `createControl`

**Value**

A Cyclops prior object of class inheriting from "cyclopsPrior" and "cyclopsFunctionalPrior" for use with `fitCyclopsModel`.

**createControl**

Create a Cyclops control object

**Description**

createControl creates a Cyclops control object for use with `fitCyclopsModel`.
createControl

Usage

createControl(
  maxIterations = 1000,
  tolerance = 1e-06,
  convergenceType = "gradient",
  cvType = "auto",
  fold = 10,
  lowerLimit = 0.01,
  upperLimit = 20,
  gridSteps = 10,
  cvRepetitions = 1,
  minCVData = 100,
  noiseLevel = "silent",
  threads = 1,
  seed = NULL,
  resetCoefficients = FALSE,
  startingVariance = -1,
  useKKTSwindle = FALSE,
  tuneSwindle = 10,
  selectorType = "auto",
  initialBound = 2,
  maxBoundCount = 5,
  algorithm = "ccd"
)

Arguments

maxIterations  Integer: maximum iterations of Cyclops to attempt before returning a failed-to-converge error

tolerance  Numeric: maximum relative change in convergence criterion from successive iterations to achieve convergence

convergenceType  String: name of convergence criterion to employ (described in more detail below)

cvType  String: name of cross validation search. Option "auto" selects an auto-search following BBR. Option "grid" selects a grid-search cross validation

fold  Numeric: Number of random folds to employ in cross validation

lowerLimit  Numeric: Lower prior variance limit for grid-search

upperLimit  Numeric: Upper prior variance limit for grid-search

gridSteps  Numeric: Number of steps in grid-search

cvRepetitions  Numeric: Number of repetitions of X-fold cross validation

minCVData  Numeric: Minimum number of data for cross validation

noiseLevel  String: level of Cyclops screen output ("silent", "quiet", "noisy")

threads  Numeric: Specify number of CPU threads to employ in cross-validation; default = 1 (auto = -1)
createControl

seed Numeric: Specify random number generator seed. A null value sets seed via `Sys.time`.
resetCoefficients Logical: Reset all coefficients to 0 between model fits under cross-validation
startingVariance Numeric: Starting variance for auto-search cross-validation; default = -1 (use estimate based on data)
useKKTSwindle Logical: Use the Karush-Kuhn-Tucker conditions to limit search
tuneSwindle Numeric: Size multiplier for active set
selectorType String: name of exchangeable sampling unit. Option "byPid" selects entire strata. Option "byRow" selects single rows. If set to "auto", "byRow" will be used for all models except conditional models where the average number of rows per stratum is smaller than the number of strata.
initialBound Numeric: Starting trust-region size
maxBoundCount Numeric: Maximum number of tries to decrease initial trust-region size
algorithm String: name of fitting algorithm to employ; default is 'ccd'

Value

A Cyclops control object of class inheriting from "cyclopsControl" for use with `fitCyclopsModel`.

Examples

```r
#Generate some simulated data:
sim <- simulateCyclopsData(nstrata = 1, nrows = 1000, ncovars = 2, eCovarsPerRow = 0.5, model = "poisson")
cyclopsData <- convertToCyclopsData(sim$outcomes, sim$covariates, modelType = "pr", addIntercept = TRUE)

#Define the prior and control objects to use cross-validation for finding the optimal hyperparameter:
prior <- createPrior("laplace", exclude = 0, useCrossValidation = TRUE)
control <- createControl(cvType = "auto", noiseLevel = "quiet")

#Fit the model
fit <- fitCyclopsModel(cyclopsData,prior = prior, control = control)

#Find out what the optimal hyperparameter was:
getHyperParameter(fit)

#Extract the current log-likelihood, and coefficients
logLik(fit)
coef(fit)

#We can only retrieve the confidence interval for unregularized coefficients:
confint(fit, c(0))
```
createCyclopsData

createCyclopsData creates a Cyclops data object from an R formula or data matrices.

Usage

createCyclopsData(
  formula,
  sparseFormula,
  indicatorFormula,
  modelType,
  data,
  subset = NULL,
  weights = NULL,
  censorWeights = NULL,
  offset = NULL,
  time = NULL,
  pid = NULL,
  y = NULL,
  type = NULL,
  dx = NULL,
  sx = NULL,
  ix = NULL,
  model = FALSE,
  normalize = NULL,
  floatingPoint = 64,
  method = "cyclops.fit"
)

Arguments

formula An object of class "formula" that provides a symbolic description of the numerically dense model response and terms.
sparseFormula An object of class "formula" that provides a symbolic description of numerically sparse model terms.
indicatorFormula An object of class "formula" that provides a symbolic description of \{0,1\} model terms.
modelType character string: Valid types are listed below.
data An optional data frame, list or environment containing the variables in the model.
subset Currently unused
weights Currently unused
createCyclopsData

censorWeights Vector of subject-specific censoring weights (between 0 and 1). Currently only supported in modelType = "fgr".
offset Currently unused
time Currently undocumented
pid Optional vector of integer stratum identifiers. If supplied, all rows must be sorted by increasing identifiers
y Currently undocumented
type Currently undocumented
dx Optional dense "Matrix" of covariates
sx Optional sparse "Matrix" of covariates
ix Optional {0,1} "Matrix" of covariates
model Currently undocumented
normalize String: Name of normalization for all non-indicator covariates (possible values: stdev, max, median)
floatingPoint Integer: Floating-point representation size (32 or 64)
method Currently undocumented

Details

This function creates a Cyclops model data object from R "formula" or directly from numeric vectors and matrices to define the model response and covariates. If specifying a model using a "formula", then the left-hand side define the model response and the right-hand side defines dense covariate terms. Objects provided with "sparseFormula" and "indicatorFormula" must be include left-hand side responses and terms are coerced into sparse and indicator representations for computational efficiency.

Items to discuss: * Only use formula or (y,dx,...) * stratum() in formula * offset() in formula * when "stratum" (renamed from pid) are necessary * when "time" are necessary

Value

A list that contains a Cyclops model data object pointer and an operation duration

Models

Currently supported model types are:

"ls"  Least squares
"pr"  Poisson regression
"lr"  Logistic regression
"clr" Conditional logistic regression
"cpr" Conditional Poisson regression
"seccs" Self-controlled case series
"cox" Cox proportional hazards regression
"fgr" Fine-Gray proportional subdistribution hazards regression
createNonSeparablePrior

Create a Cyclops prior object that returns the MLE of non-separable coefficients

Description

createNonSeparablePrior creates a Cyclops prior object for use with fitCyclopsModel.

Usage

createNonSeparablePrior(maxIterations = 10, ...)

Arguments

maxIterations Numeric: maximum iterations to achieve convergence
...

Additional argument(s) for fitCyclopsModel

Value

A Cyclops prior object of class inheriting from "cyclopsPrior" for use with fitCyclopsModel.

Examples

c prior <- createNonSeparablePrior()
createParameterizedPrior

*Create a Cyclops parameterized prior object*

**Description**

createParameterizedPrior creates a Cyclops prior object for use with `fitCyclopsModel` in which arbitrary R functions parameterize the prior location and variance.

**Usage**

```r
createParameterizedPrior(
  priorType, parameterize, values, useCrossValidation = FALSE, forceIntercept = FALSE
)
```

**Arguments**

- `priorType`: Character vector: specifies prior distribution. See below for options
- `parameterize`: Function list: parameterizes location and variance
- `values`: Numeric vector: initial parameter values
- `useCrossValidation`: Logical: Perform cross-validation to determine parameters.
- `forceIntercept`: Logical: Force intercept coefficient into prior

**Value**

A Cyclops prior object of class inheriting from "cyclopsPrior" and "cyclopsFunctionalPrior" for use with `fitCyclopsModel`.

createPrior

*Create a Cyclops prior object*

**Description**

createPrior creates a Cyclops prior object for use with `fitCyclopsModel`. 
createPrior

Usage

createPrior(
  priorType,
  variance = 1,
  exclude = c(),
  graph = NULL,
  neighborhood = NULL,
  useCrossValidation = FALSE,
  forceIntercept = FALSE
)

Arguments

priorType  Character: specifies prior distribution. See below for options
variance  Numeric: prior distribution variance
exclude  A vector of numbers or covariateId names to exclude from prior
graph  Child-to-parent mapping for a hierarchical prior
neighborhood  A list of first-order neighborhoods for a partially fused prior
useCrossValidation  Logical: Perform cross-validation to determine prior variance.
forceIntercept  Logical: Force intercept coefficient into prior

Value

A Cyclops prior object of class inheriting from "cyclopsPrior" for use with fitCyclopsModel.

Prior types

We specify all priors in terms of their variance parameters. Similar fitting tools for regularized regression often parameterize the Laplace distribution in terms of a rate "lambda" per observation. See "glmnet", for example.

\[
\text{variance} = \frac{2}{\text{nobs} \times \lambda^2} \quad \text{or} \quad \lambda = \sqrt{\frac{2}{\text{variance}}} / \text{nobs}
\]

Examples

#Generate some simulated data:
sim <- simulateCyclopsData(nstrata = 1, nrows = 1000, ncovars = 2, eCovarsPerRow = 0.5,
  model = "poisson")
cyclopsData <- convertToCyclopsData(sim$outcomes, sim$covariates, modelType = "pr",
  addIntercept = TRUE)

#Define the prior and control objects to use cross-validation for finding the
#optimal hyperparameter:
prior <- createPrior("laplace", exclude = 0, useCrossValidation = TRUE)
control <- createControl(cvType = "auto", noiseLevel = "quiet")

#Fit the model
fit <- fitCyclopsModel(cyclopsData, prior = prior, control = control)
#Find out what the optimal hyperparameter was:
getHyperParameter(fit)

#Extract the current log-likelihood, and coefficients
logLik(fit)
coef(fit)

#We can only retrieve the confidence interval for unregularized coefficients:
confint(fit, c(0))

cyclops

Cyclops: Cyclic coordinate descent for logistic, Poisson and survival analysis

Description

The Cyclops package incorporates cyclic coordinate descent and majorization-minimization approaches to fit a variety of regression models found in large-scale observational healthcare data. Implementations focus on computational optimization and fine-scale parallelization to yield efficient inference in massive datasets.

fitCyclopsModel

Fit a Cyclops model

Description

fitCyclopsModel fits a Cyclops model data object

Usage

fitCyclopsModel(
  cyclopsData,
  prior = createPrior("none"),
  control = createControl(),
  weights = NULL,
  forceNewObject = FALSE,
  returnEstimates = TRUE,
  startingCoefficients = NULL,
  fixedCoefficients = NULL,
  computeDevice = "native"
)
Arguments

cyclopsData A Cyclops data object
prior A prior object. More details are given below.
control A "cyclopsControl" object constructed by createControl
weights Vector of 0/1 weights for each data row
forceNewObject Logical, forces the construction of a new Cyclops model fit object
returnEstimates Logical, return regression coefficient estimates in Cyclops model fit object
startingCoefficients Vector of starting values for optimization
fixedCoefficients Vector of booleans indicating if coefficient should be fix
computeDevice String: Name of compute device to employ; defaults to "native" C++ on CPU

Details

This function performs numerical optimization to fit a Cyclops model data object.

Value

A list that contains a Cyclops model fit object pointer and an operation duration

Prior

Currently supported prior types are:

"none" Useful for finding MLE
"laplace" L_1 regularization
"normal" L_2 regularization

References


Examples

```r
## Dobson (1990) Page 93: Randomized Controlled Trial :
counts <- c(18,17,15,20,10,20,25,13,12)
outcome <- gl(3,1,9)
```
```r
treatment <- gl(3,3)
cyclopsData <- createCyclopsData(counts ~ outcome + treatment, modelType = "pr")
cyclopsFit <- fitCyclopsModel(cyclopsData, prior = createPrior("none"))
coef(cyclopsFit)
confint(cyclopsFit, c("outcome2","treatment3"))
predict(cyclopsFit)
```

---

**fitCyclopsSimulation**  
*Fit simulated data*

**Description**  
fitCyclopsSimulation fits simulated Cyclops data using Cyclops or a standard routine. This function is useful for simulation studies comparing the performance of Cyclops when considering large, sparse datasets.

**Usage**

```r
fitCyclopsSimulation(
  sim, 
  useCyclops = TRUE, 
  model = "logistic", 
  coverage = TRUE, 
  includePenalty = FALSE
)
```

**Arguments**

- `sim`  
  A simulated Cyclops dataset generated via `simulateCyclopsData`

- `useCyclops`  
  Logical: use Cyclops or a standard routine

- `model`  
  String: Fitted regression model type

- `coverage`  
  Logical: report coverage statistics

- `includePenalty`  
  Logical: include regularized regression penalty in computing profile likelihood based confidence intervals

---

**getCovariateIds**  
*Get covariate identifiers*

**Description**  
getCovariateIds returns a vector of integer64 covariate identifiers in a Cyclops data object

**Usage**

```r
covariateIds(object)
```
**getCovariateTypes**

**Arguments**

object  
A Cyclops data object

**Description**

getCovariateTypes returns a vector covariate types in a Cyclops data object

**Usage**

getcovariateTypes(object, covariateLabel)

**Arguments**

object  
A Cyclops data object

covariateLabel  
Integer vector: covariate identifiers to return

---

**getCyclopsProfileLogLikelihood**

*Profile likelihood for Cyclops model parameters*

**Description**

getCyclopsProfileLogLikelihood evaluates the profile likelihood at a grid of parameter values.

**Usage**

getcyclopsProfileLogLikelihood(
    object,
    parm,
    x = NULL,
    bounds = NULL,
    tolerance = 0.001,
    initialGridSize = 10,
    includePenalty = TRUE
)
getFineGrayWeights

Arguments

- **object**: Fitted Cyclops model object
- **parm**: Specification of which parameter requires profiling, either a vector of numbers of covariateId names
- **x**: Vector of values of the parameter
- **bounds**: Pair of values to bound adaptive profiling
- **tolerance**: Absolute tolerance allowed for adaptive profiling
- **initialGridSize**: Initial grid size for adaptive profiling
- **includePenalty**: Logical: Include regularized covariate penalty in profile

Value

A data frame containing the profile log likelihood. Returns NULL when the adaptive profiling fails to converge.

getFineGrayWeights creates a Surv object that forces in competing risks and the IPCW needed for Fine-Gray estimation.

Description

getFineGrayWeights creates a list Surv object and vector of weights required for estimation.

Usage

getFineGrayWeights(ftime, fstatus, cencode = 0, failcode = 1)

Arguments

- **ftime**: Numeric: Observed event (failure) times
- **fstatus**: Numeric: Observed event (failure) types
- **cencode**: Numeric: Code to denote censored observations (Default is 0)
- **failcode**: Numeric: Code to denote event of interest (Default is 1)

Value

A list that returns both an object of class Surv that forces in the competing risks indicators and a vector of weights needed for parameter estimation.

Examples

```r
ftime <- c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
fstatus <- c(1, 2, 0, 1, 2, 0, 1, 2, 0, 1)
getFineGrayWeights(ftime, fstatus, cencode = 0, failcode = 1)
```
getFloatingPointSize  
\textit{Get floating point size}

\textbf{Description} 
getFloatingPointSize returns the floating-point representation size in a Cyclops data object

\textbf{Usage} 
getFloatingPointSize(object)

\textbf{Arguments} 
object  
A Cyclops data object

getHyperParameter  
\textit{Get hyperparameter}

\textbf{Description} 
getHyperParameter returns the current hyper parameter in a Cyclops model fit object

\textbf{Usage} 
getHyperParameter(object)

\textbf{Arguments} 
object  
A Cyclops model fit object

\textbf{Examples} 

```r
#Generate some simulated data:
sim <- simulateCyclopsData(nstrata = 1, nrows = 1000, ncovars = 2, eCovarsPerRow = 0.5,
model = "poisson")
cyclopsData <- convertToCyclopsData(sim$outcomes, sim$covariates, modelType = "pr",
addIntercept = TRUE)

#Define the prior and control objects to use cross-validation for finding the
#optimal hyperparameter:
prior <- createPrior("laplace", exclude = 0, useCrossValidation = TRUE)
control <- createControl(cvType = "auto", noiseLevel = "quiet")

#Fit the model
fit <- fitCyclopsModel(cyclopsData, prior = prior, control = control)

#Find out what the optimal hyperparameter was:
```

getHyperParameter(fit)

# Extract the current log-likelihood, and coefficients
logLik(fit)
coef(fit)

# We can only retrieve the confidence interval for unregularized coefficients:
confint(fit, c(0))

---

getNumberOfCovariates  Get total number of covariates

Description

getNumberOfCovariates returns the total number of covariates in a Cyclops data object

Usage

getNumberOfCovariates(object)

Arguments

object  A Cyclops data object

---

getNumberOfRows  Get total number of rows

Description

getNumberOfRows returns the total number of outcome rows in a Cyclops data object

Usage

getNumberOfRows(object)

Arguments

object  A Cyclops data object
**getNumberOfStrata**  
*Get number of strata*

**Description**

`getNumberOfStrata` return the number of unique strata in a Cyclops data object

**Usage**

```
getNumberOfStrata(object)
```

**Arguments**

- `object`: A Cyclops data object

**getUnivariableCorrelation**  
*Get univariable correlation*

**Description**

`getUnivariableCorrelation` reports covariates that have high correlation with the outcome

**Usage**

```
getUnivariableCorrelation(cyclopsData, covariates = NULL, threshold = 0)
```

**Arguments**

- `cyclopsData`: A Cyclops data object
- `covariates`: Integer or string vector: list of covariates to report; default (NULL) implies all covariates
- `threshold`: Correlation threshold for reporting

**Value**

A list of covariates whose absolute correlation with the outcome is greater than or equal to the threshold
getUnivariableSeparability

*Get univariable linear separability*

**Description**

getUnivariableSeparability reports covariates that are univariably separable with the outcome.

**Usage**

```r
getUnivariableSeparability(cyclopsData, covariates = NULL)
```

**Arguments**

- `cyclopsData`: A Cyclops data object.
- `covariates`: Integer or string vector; list of covariates to report; default (NULL) implies all covariates.

**Value**

A list of covariates that are univariably separable with the outcome.

---

isInitialized

*Check if a Cyclops data object is initialized*

**Description**

isInitialized determines if a Cyclops data object is properly initialized and remains in memory. Cyclops data objects do not serialize/deserialize their back-end memory across R sessions.

**Usage**

```r
isInitialized(object)
```

**Arguments**

- `object`: Cyclops data object to test.
Description

`logLik` returns the current log-likelihood of the fit in a Cyclops model fit object.

Usage

```r
## S3 method for class 'cyclopsFit'
logLik(object, ...)
```

Arguments

- `object`: A Cyclops model fit object
- `...`: Additional arguments

Examples

```r
# Generate some simulated data:
sim <- simulateCyclopsData(nstrata = 1, nrows = 1000, ncovars = 2, eCovarsPerRow = 0.5,
                           model = "poisson")
cyclopsData <- convertToCyclopsData(sim$outcomes, sim$covariates, modelType = "pr",
                                    addIntercept = TRUE)

# Define the prior and control objects to use cross-validation for finding the
# optimal hyperparameter:
prior <- createPrior("laplace", exclude = 0, useCrossValidation = TRUE)
control <- createControl(cvType = "auto", noiseLevel = "quiet")

# Fit the model
fit <- fitCyclopsModel(cyclopsData, prior = prior, control = control)

# Find out what the optimal hyperparameter was:
getHyperParameter(fit)

# Extract the current log-likelihood, and coefficients
logLik(fit)
coef(fit)

# We can only retrieve the confidence interval for unregularized coefficients:
confint(fit, c(0))
```
meanLinearPredictor  \textit{Calculates xbar*beta}

\section*{Description}
meanLinearPredictor computes xbar*beta for model fit

\section*{Usage}
\texttt{meanLinearPredictor(cyclopsFit)}

\section*{Arguments}
cyclopsFit  A Cyclops model fit object

\section*{mse  \textit{Mean squared error}}

\section*{Description}
mse computes the mean squared error between two numeric vectors

\section*{Usage}
mse(goldStandard, estimates)

\section*{Arguments}
goldStandard  Numeric vector
estimates  Numeric vector

\section*{Value}
MSE(goldStandard, estimates)
Multitype

Create a multitype outcome object

Description

Multitype creates a multitype outcome object, usually used as a response variable in a hierarchical Cyclops model fit.

Usage

Multitype(y, type)

Arguments

y Numeric: Response count(s)

Type Numeric or factor: Response type

Value

An object of class Multitype with length equal to the length of y and type.

Examples

Multitype(c(0,1,0), as.factor(c("A","A","B")))

oxford

Oxford self-controlled case series data

Description

A dataset containing the MMR vaccination / meningitis in Oxford example from Farrington and Whitaker. There are 10 patients comprising 38 unique exposure intervals.

Usage

data(oxford)
Format

A data frame with 38 rows and 6 variables:

- **indiv**: patient identifier
- **event**: number of events in interval
- **interval**: interval length in days
- **agegr**: age group
- **exgr**: exposure group
- **loginterval**: log interval length ...

predict.cyclopsFit    Model predictions

Description

predict.cyclopsFit computes model response-scale predictive values for all data rows

Usage

```r
## S3 method for class 'cyclopsFit'
predict(object, newOutcomes, newCovariates, ...)
```

Arguments

- `object`: A Cyclops model fit object
- `newOutcomes`: An optional data frame or Andromeda table object, similar to the object used in `convertToCyclopsData`
- `newCovariates`: An optional data frame or Andromeda table object, similar to the object used in `convertToCyclopsData`
- `...`: Additional arguments

print.cyclopsData    Print a Cyclops data object

Description

print.cyclopsData displays information about a Cyclops data model object.

Usage

```r
## S3 method for class 'cyclopsData'
print(x, show.call = TRUE, ...)
```
Arguments

- `x` A Cyclops data model object
- `show.call` Logical: display last call to construct the Cyclops data model object
- `...` Additional arguments

Description

`print.cyclopsFit` displays information about a Cyclops model fit object.

Usage

```r
## S3 method for class 'cyclopsFit'
print(x, show.call = TRUE, ...)
```

Arguments

- `x` A Cyclops model fit object
- `show.call` Logical: display last call to update the Cyclops model fit object
- `...` Additional arguments

readCyclopsData

Description

`readCyclopsData` reads a Cyclops-formatted text file.

Usage

```r
readCyclopsData(fileName, modelType)
```

Arguments

- `fileName` Name of text file to be read. If `fileName` does not contain an absolute path,
- `modelType` character string: Valid types are listed below.

Details

This function reads a Cyclops-formatted text file and returns a Cyclops data object. The first line of the file may start with `'#'`, indicating that it contains header options. Valid header options are:
readCyclopsData

row_label  (assume file contains a numeric column of unique row identifiers)
stratum_label (assume file contains a numeric column of stratum identifiers)
weight  (assume file contains a column of row-specific model weights, currently unused)
offset (assume file contains a dense column of linear predictor offsets)
bbr_outcome (assume logistic outcomes are encoded -1/+1 following BBR)
log_offset (assume file contains a dense column of values x_i for which log(x_i) is the offset)
add_intercept (automatically include an intercept column of all 1s for each entry)
indicator_only (assume all covariates 0/1-valued and only covariate name is given)
sparse  (force all BBR formatted covariates to be represented as sparse, instead of
sparse-indicator, columns .. really only for debugging)
dense  (force all BBR formatted covariates to be represented as dense columns.. really
only for debugging)

Successive lines of the file are white-space delimited and follow the format:

[Row ID] {Stratum ID} [Weight] <Outcome> {Censored} {Offset} <BBR covariates>

• [optional]
• <required>
• {required or optional depending on model}

Bayesian binary regression (BBR) covariates are white-space delimited and generally in a sparse
"<name>:<value>" format, where 'name' must (currently) be numeric and 'value' is non-zero. If
option 'indicator_only' is specified, then format is simply '"name"'. 'Row ID' and 'Stratum ID'
must be numeric, and rows must be sorted such that equal 'Stratum ID' are consecutive. 'Stratum
ID' is required for 'clr' and 'sccs' models. 'Censored' is required for a 'cox' model. 'Offset' is
(currently) required for a 'sccs' model.

Value

A list that contains a Cyclops model data object pointer and an operation duration

Models

Currently supported model types are:

"ls"  Least squares
"pr"  Poisson regression
"lr"  Logistic regression
"clr"  Conditional logistic regression
"cpr"  Conditional Poisson regression
"sccs"  Self-controlled case series
"cox"  Cox proportional hazards regression
"fgr"  Fine-Gray proportional subdistribution hazards regression
simulateCyclopsData

## Not run:
```r
dataPtr = readCyclopsData(system.file("extdata/infert_ccd.txt", package="Cyclops"), "clr")
```
## End(Not run)

### Description

`simulateCyclopsData` generates a simulated large, sparse data set for use by `fitCyclopsSimulation`.

### Usage

```r
simulateCyclopsData(
  nstrata = 200,
  nrows = 10000,
  ncovars = 20,
  effectSizeSd = 1,
  zeroEffectSizeProp = 0.9,
  eCovarsPerRow = ncovars/100,
  model = "survival"
)
```

### Arguments

- **nstrata**: Numeric: Number of strata
- **nrows**: Numeric: Number of observation rows
- **ncovars**: Numeric: Number of covariates
- **effectSizeSd**: Numeric: Standard derivation of the non-zero simulated regression coefficients
- **zeroEffectSizeProp**: Numeric: Expected proportion of zero effect size
- **eCovarsPerRow**: Number: Effective number of non-zero covariates per data row
- **model**: String: Simulation model. Choices are: logistic, poisson or survival

### Value

A simulated data set
Examples

#Generate some simulated data:
sim <- simulateCyclopsData(nstrata = 1, nrows = 1000, ncovars = 2, eCovarsPerRow = 0.5,  
model = "poisson")
cyclopsData <- convertToCyclopsData(sim$outcomes, sim$covariates, modelType = "pr",  
addIntercept = TRUE)

#Define the prior and control objects to use cross-validation for finding the  
#optimal hyperparameter:
prior <- createPrior("laplace", exclude = 0, useCrossValidation = TRUE)  
control <- createControl(cvType = "auto", noiseLevel = "quiet")

#Fit the model
fit <- fitCyclopsModel(cyclopsData,prior = prior, control = control)

#Find out what the optimal hyperparameter was:  
getHyperParameter(fit)

#Extract the current log-likelihood, and coefficients
logLik(fit)
coef(fit)

#We can only retrieve the confidence interval for unregularized coefficients:  
confint(fit, c(0))

summary.cyclopsData

Cyclops data object summary

Description

summary.cyclopsData summarizes the data held in an Cyclops data object.

Usage

## S3 method for class 'cyclopsData'
summary(object, ...)

Arguments

object A Cyclops data object

... Additional arguments

Value

Returns a data.frame that reports simply summarize statistics for each covariate in a Cyclops data object.
**survfit.cyclopsFit**

*Calculate baseline hazard function*

**Description**

`survfit.cyclopsFit` computes baseline hazard function

**Usage**

```r
## S3 method for class 'cyclopsFit'
survfit(cyclopsFit, type = "aalen")
```

**Arguments**

- `cyclopsFit`: A Cyclops survival model fit object
- `type`: type of baseline survival, choices are: "aalen" (Breslow)

**Value**

Baseline survival function for mean covariates

---

**vcov.cyclopsFit**

*Calculate variance-covariance matrix for a fitted Cyclops model object*

**Description**

`vcov.cyclopsFit` returns the variance-covariance matrix for all covariates of a Cyclops model object

**Usage**

```r
## S3 method for class 'cyclopsFit'
vcov(object, control, overrideNoRegularization = FALSE, ...)
```

**Arguments**

- `object`: A fitted Cyclops model object
- `control`: A "cyclopsControl" object constructed by `createControl`
- `overrideNoRegularization`: Logical: Enable variance-covariance estimation for regularized parameters
- `...`: Additional argument(s) for methods

**Value**

A matrix of the estimates covariances between all covariate estimates.
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