Package 'PLNmodels'

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Title Poisson Lognormal Models

Version 0.10.6

Description The Poisson-lognormal model and variants can be used for a variety of multivariate problems when count data are at play, including principal component analysis for count data (Chiquet, Mariadassou and Robin, 2018 <doi:10.1214/18-AOAS1177>), discriminant analysis and network inference (Chiquet, Mariadassou and Robin, 2018 <http://proceedings.mlr.press/v97/chiquet19a.html>). Implements variational algorithms to fit such models accompanied with a set of functions for visualization and diagnostic.

URL https://jchiquet.github.io/PLNmodels/

BugReports https://github.com/jchiquet/PLNmodels/issues

License GPL (>= 3)

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'PLNmodels-package.R' 'PLNnetwork.R'
'PLNnetworkfamily-S3methods.R' 'PLNnetworkfamily-class.R'
'PLNnetworkfit-S3methods.R' 'PLNnetworkfit-class.R'
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R topics documented:

`coef.PLNfit` *Extract model coefficients*

Description

Extracts model coefficients from objects returned by `PLN()` and its variants

Usage

```
## S3 method for class 'PLNfit'
coef(object, type = c("main", "covariance"), ...)
```

Arguments

`object`	an R6 object with class `PLNfit`
`type`	type of parameter that should be extracted. Either "main" (default) for Θ or "covariance" for Σ
`...`	additional parameters for S3 compatibility. Not used

Value

A matrix of coefficients extracted from the PLNfit model.

See Also

`sigma.PLNfit()`, `vcov.PLNfit()`, `standard_error.PLNfit()`

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPLN <- PLN(Abundance ~ 1 + offset(log(Offset)), data = trichoptera)
coef(myPLN) ## Theta
coef(myPLN, type = "covariance") ## Sigma
```

coef.PLNLDAfit *Extracts model coefficients from objects returned by* PLNLDA()

Description

The method for objects returned by PLNLDA() only returns coefficients associated to the

$$\Theta$$

part of the model (see the PLNLDA vignette for mathematical details).

Usage

```
## S3 method for class 'PLNLDAfit'
coef(object, ...)
```

Arguments

object	an R6 object with class PLNfit
...	additional parameters for S3 compatibility. Not used

Value

Either NULL or a matrix of coefficients extracted from the PLNLDAfit model.

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPLNLDA <- PLNLDA(Abundance ~ Wind, grouping = Group, data = trichoptera)
coef(myPLNLDA)
```

coefficient_path *Extract the regularization path of a PLNnetwork fit*

Description

Extract the regularization path of a PLNnetwork fit

Usage

```
coefficient_path(Robject, precision = TRUE, corr = TRUE)
```

Arguments

Robject	an object with class PLNnetworkfamily, i.e. an output from PLNnetwork()
precision	a logical, should the coefficients of the precision matrix Omega or the covariance matrix Sigma be sent back. Default is TRUE.
corr	a logical, should the correlation (partial in case precision = TRUE) be sent back. Default is TRUE.

Value

Sends back a tibble/data.frame.

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
fits <- PLNnetwork(Abundance ~ 1, data = trichoptera)
head(coefficient_path(fits))
```

---

compute_offset *Compute offsets from a count data using one of several normalization schemes*

Description

Computes offsets from the count table using one of several normalization schemes (TSS, CSS, RLE, GMPR, etc) described in the literature.

Usage

```
compute_offset(counts, offset = c("TSS", "GMPR", "RLE", "CSS", "none"), ...)
```

Arguments

counts	Required. An abundance count table, preferably with dimensions names and species as columns.
offset	Optional. Normalization scheme used to compute scaling factors used as offset during PLN inference. Available schemes are "TSS" (Total Sum Scaling, default), "CSS" (Cumulative Sum Scaling, used in metagenomeSeq), "RLE" (Relative Log Expression, used in DESeq2), "GMPR" (Geometric Mean of Pairwise Ratio, introduced in Chen et al., 2018) or "none". Alternatively the user can supply its own vector or matrix of offsets (see note for specification of the user-supplied offsets).
...	Additional parameters passed on to specific methods (for now CSS and RLE)

Details

RLE has an additional `pseudocounts` arguments to add pseudocounts to the observed counts (defaults to 0). CSS has an additional `reference` argument to choose the location function used to compute the reference quantiles (defaults to `median` as in the Nature publication but can be set to `mean` to reproduce behavior of functions cumNormStat* from metagenomeSeq). Note that (i) CSS normalization fails when the median absolute deviation around quantiles does not become instable for high quantiles (limited count variations both within and across samples) and/or one sample has less than two positive counts, (ii) RLE fails when there are no common species across all samples and (iii) GMPR fails if a sample does not share any species with all other samples.

Value

If `offset = "none"`, `NULL` else a vector of length `nrow(counts)` with one offset per sample.

References

Chen, L., Reeve, J., Zhang, L., Huang, S., Wang, X. and Chen, J. (2018) GMPR: A robust normalization method for zero-inflated count data with application to microbiome sequencing data. PeerJ, 6, e4600 https://doi.org/10.7717/peerj.4600

Paulson, J. N., Colin Stine, O., Bravo, H. C. and Pop, M. (2013) Differential abundance analysis for microbial marker-gene surveys. Nature Methods, 10, 1200-1202 http://dx.doi.org/10.1038/nmeth.2658

Anders, S. and Huber, W. (2010) Differential expression analysis for sequence count data. Genome Biology, 11, R106 https://doi.org/10.1186/gb-2010-11-10-r106

Examples

```
data(trichoptera)
counts <- trichoptera$Abundance
compute_offset(counts)
## Other normalization schemes
compute_offset(counts, offset = "GMPR")
compute_offset(counts, offset = "RLE", pseudocounts = 1)
## User supplied offsets
my_offset <- setNames(rep(1, nrow(counts)), rownames(counts))
compute_offset(counts, offset = my_offset)
```

---

extract_probs *Extract edge selection frequency in bootstrap subsamples*

Description

Extracts edge selection frequency in networks reconstructed from bootstrap subsamples during the stars stability selection procedure, as either a matrix or a named vector. In the latter case, edge names follow igraph naming convention.

Usage

```
extract_probs(
  Robject,
  penalty = NULL,
  index = NULL,
  crit = c("StARS", "BIC", "EBIC"),
  format = c("matrix", "vector"),
  tol = 1e-05
)
```

Arguments

Robject	an object with class PLNnetworkfamily, i.e. an output from PLNnetwork()
penalty	penalty used for the bootstrap subsamples
index	Integer index of the model to be returned. Only the first value is taken into account.
crit	a character for the criterion used to performed the selection. Either "BIC", "ICL", "EBIC", "StARS", "R_squared". Default is ICL for PLNPCA, and BIC for PLNnetwork. If StARS (Stability Approach to Regularization Selection) is chosen and stability selection was not yet performed, the function will call the method stability_selection() with default argument.
format	output format. Either a matrix (default) or a named vector.
tol	tolerance for rounding error when comparing penalties.

Value

Either a matrix or named vector of edge-wise probabilities. In the latter case, edge names follow igraph convention.

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
nets <- PLNnetwork(Abundance ~ 1 + offset(log(Offset)), data = trichoptera)
## Not run:
stability_selection(nets)
probs <- extract_probs(nets, crit = "StARS", format = "vector")
probs

## End(Not run)

## Not run:
## Add edge attributes to graph using igraph
net_stars <- getBestModel(nets, "StARS")
g <- plot(net_stars, type = "partial_cor", plot=F)
library(igraph)
E(g)$prob <- probs[as_ids(E(g))]
g
```

```
## End(Not run)
```

`fisher` *Fisher information matrix for Theta*

Description

Extracts Fisher information matrix of Θ from objects returned by `PLN` and its variants. Fisher matrix is computed using one of two approximation scheme: wald (default, conservative, gives large confidence interval) or louis (anticonservative). Note that the Fisher information matrix is the full-data version (scaled by the number of observations), usually noted

$$I_n(\theta)$$

.

Usage

```
fisher(object, type)

## S3 method for class 'PLNfit'
fisher(object, type = c("wald", "louis"))
```

Arguments

`object`	an R6 object with class PLNfit
`type`	Either `wald` (default) or `louis`. Approximation scheme used to compute the Fisher information matrix

Value

A block-diagonal matrix with p (number of species) blocks of size d (number of covariates), assuming Θ is a matrix of size d * p.

Methods (by class)

- `PLNfit`: Fisher information matrix for PLNfit

See Also

`standard_error` for standard errors

`fitted.PLNfit` *Extracts model fitted values from objects returned by* `PLN()` *and its variants*

Description

Extracts model fitted values from objects returned by `PLN()` and its variants

Usage

```
## S3 method for class 'PLNfit'
fitted(object, ...)
```

Arguments

`object`	an R6 object with class `PLNfit`
`...`	additional parameters for S3 compatibility. Not used

Value

A matrix of Fitted values extracted from the object object.

`getBestModel.PLNPCAfamily` *Best model extraction from a collection of models*

Description

Best model extraction from a collection of models

Usage

```
## S3 method for class 'PLNPCAfamily'
getBestModel(Robject, crit = c("ICL", "BIC", "R_squared"), ...)

getBestModel(Robject, crit, ...)

## S3 method for class 'PLNnetworkfamily'
getBestModel(
  Robject,
  crit = c("BIC", "loglik", "R_squared", "EBIC", "StARS"),
  ...
)
```

Arguments

Robject	an object with class PLNPCAfamilly ot PLNnetworkfamily
crit	a character for the criterion used to performed the selection. Either "BIC", "ICL", "EBIC", "StARS", "R_squared". Default is ICL for PLNPCA, and BIC for PLNnetwork. If StARS (Stability Approach to Regularization Selection) is chosen and stability selection was not yet performed, the function will call the method stability_selection() with default argument.
...	additional parameters for StARS criterion (only for PLNnetwork). stability, a scalar indicating the target stability (= 1 - 2 beta) at which the network is selected. Default is 0.9.

Value

Send back an object with class PLNPCAfit or PLNnetworkfit

Methods (by class)

- PLNPCAfamily: Model extraction for PLNPCAfamily
- PLNnetworkfamily: Model extraction for PLNnetworkfamily

Examples

```
## Not run:
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPCA <- PLNPCA(Abundance ~ 1 + offset(log(Offset)), data = trichoptera, ranks = 1:4)
myModel <- getBestModel(myPCA)

## End(Not run)
```

---

getModel.PLNPCAfamily *Model extraction from a collection of models*

Description

Model extraction from a collection of models

Usage

```
## S3 method for class 'PLNPCAfamily'
getModel(Robject, var, index = NULL)

getModel(Robject, var, index)

## S3 method for class 'PLNnetworkfamily'
getModel(Robject, var, index = NULL)
```

Arguments

Robject	an R6 object with class PLNPCAfamily or PLNnetworkfamily
var	value of the parameter (rank for PLNPCA, sparsity for PLNnetwork) that identifies the model to be extracted from the collection. If no exact match is found, the model with closest parameter value is returned with a warning.
index	Integer index of the model to be returned. Only the first value is taken into account.

Value

Sends back an object with class PLNPCAfit or PLNnetworkfit.

Methods (by class)

- PLNPCAfamily: Model extraction for PLNPCAfamily
- PLNnetworkfamily: Model extraction for PLNnetworkfamily

Examples

```
## Not run:
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPCA <- PLNPCA(Abundance ~ 1 + offset(log(Offset)), data = trichoptera, ranks = 1:5)
myModel <- getModel(myPCA, 2)

## End(Not run)
```

---

mollusk *Mollusk data set*

Description

This data set gives the abundance of 32 mollusk species in 163 samples. For each sample, 4 additional covariates are known.

Usage

```
mollusk
```

Format

A list with 2 two data frames:

Abundance a 163 x 32 data frame of abundancies/counts (163 samples and 32 mollusk species)

Covariate a 163 x 4 data frame of covariates:

site a factor with 8 levels indicating the sampling site

season a factor with 4 levels indicating the season

method a factor with 2 levels for the method of sampling - wood or string

duration a numeric with 3 levels for the time of exposure in week

In order to prepare the data for using formula in multivariate analysis (multiple outputs and inputs), use `prepare_data()`. Original data set has been extracted from ade4.

Source

Data from Richardot-Coulet, Chessel and Bournaud.

References

Richardot-Coulet, M., Chessel D. and Bournaud M. (1986) Typological value of the benthos of old beds of a large river. Methodological approach. Archiv fùr Hydrobiologie, 107, 363–383.

See Also

`prepare_data()`

Examples

```
data(mollusk)
mollusc <- prepare_data(mollusk$Abundance, mollusk$Covariate)
```

PLN *Poisson lognormal model*

Description

Fit the multivariate Poisson lognormal model with a variational algorithm. Use the (g)lm syntax for model specification (covariates, offsets, weights).

Usage

```
PLN(formula, data, subset, weights, control = list())
```

Arguments

`formula`	an object of class "formula": a symbolic description of the model to be fitted.
`data`	an optional data frame, list or environment (or object coercible by as.data.frame to a data frame) containing the variables in the model. If not found in data, the variables are taken from environment(formula), typically the environment from which PLN is called.
`subset`	an optional vector specifying a subset of observations to be used in the fitting process.
`weights`	an optional vector of observation weights to be used in the fitting process.
`control`	a list for controlling the optimization. See details.

Details

The parameter `control` is a list controlling the optimization with the following entries:

- "covariance" character setting the model for the covariance matrix. Either "full", "diagonal" or "spherical". Default is "full".
- "trace" integer for verbosity.
- "inception" Set up the initialization. By default, the model is initialized with a multivariate linear model applied on log-transformed data, and with the same formula as the one provided by the user. However, the user can provide a PLNfit (typically obtained from a previous fit), which sometimes speeds up the inference.
- "ftol_rel" stop when an optimization step changes the objective function by less than ftol multiplied by the absolute value of the parameter. Default is 1e-6 when n < p, 1e-8 otherwise.
- "ftol_abs" stop when an optimization step changes the objective function by less than ftol multiplied by the absolute value of the parameter. Default is 0
- "xtol_rel" stop when an optimization step changes every parameters by less than xtol multiplied by the absolute value of the parameter. Default is 1e-4
- "xtol_abs" stop when an optimization step changes every parameters by less than xtol multiplied by the absolute value of the parameter. Default is 0
- "maxeval" stop when the number of iteration exceeds maxeval. Default is 10000
- "maxtime" stop when the optimization time (in seconds) exceeds maxtime. Default is -1 (no restriction)
- "algorithm" the optimization method used by NLOPT among LD type, i.e. "CCSAQ", "MMA", "LBFGS", "VAR1", "VAR2". See NLOPT documentation for further details. Default is "CCSAQ".

Value

an R6 object with class `PLNfit`

See Also

The class `PLNfit`

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPLN <- PLN(Abundance ~ 1, data = trichoptera)
```

PLNfamily *An R6 Class to represent a collection of PLNfit*

Description

super class for PLNPCAfamily and PLNnetworkfamily. The R6 class benefits from S3 methods such as getBestModel(), getModel() and plot().

Details

The parameter control is a list controlling the optimization with the following entries:

- "covariance" character setting the model for the covariance matrix. Either "full", "diagonal" or "spherical". Default is "full".
- "trace" integer for verbosity.
- "inception" Set up the initialization. By default, the model is initialized with a multivariate linear model applied on log-transformed data, and with the same formula as the one provided by the user. However, the user can provide a PLNfit (typically obtained from a previous fit), which sometimes speeds up the inference.
- "ftol_rel" stop when an optimization step changes the objective function by less than ftol multiplied by the absolute value of the parameter. Default is 1e-6 when n < p, 1e-8 otherwise.
- "ftol_abs" stop when an optimization step changes the objective function by less than ftol multiplied by the absolute value of the parameter. Default is 0
- "xtol_rel" stop when an optimization step changes every parameters by less than xtol multiplied by the absolute value of the parameter. Default is 1e-4
- "xtol_abs" stop when an optimization step changes every parameters by less than xtol multiplied by the absolute value of the parameter. Default is 0
- "maxeval" stop when the number of iteration exceeds maxeval. Default is 10000
- "maxtime" stop when the optimization time (in seconds) exceeds maxtime. Default is -1 (no restriction)
- "algorithm" the optimization method used by NLOPT among LD type, i.e. "CCSAQ", "MMA", "LBFGS", "VAR1", "VAR2". See NLOPT documentation for further details. Default is "CCSAQ".

Public fields

`responses` the matrix of responses common to every models

`covariates` the matrix of covariates common to every models

`offsets` the matrix of offsets common to every models

`weights` the vector of observation weights

`inception` a PLNfit object, obtained when no sparsifying penalty is applied.

`models` a list of PLNfit object, one per penalty.

Active bindings

`criteria` a data frame with the values of some criteria (variational lower bound J, BIC, ICL and R2) for the collection of models / fits

`convergence` sends back a data frame with some convergence diagnostics associated with the optimization process (method, optimal value, etc)

Methods

Public methods:

- `PLNfamily$new()`
- `PLNfamily$postTreatment()`
- `PLNfamily$getModel()`
- `PLNfamily$plot()`
- `PLNfamily$show()`
- `PLNfamily$print()`
- `PLNfamily$clone()`

Method `new()`**:** Create a new `PLNfamily` object.

Usage:

```
PLNfamily$new(responses, covariates, offsets, weights, control)
```

Arguments:

`responses` the matrix of responses common to every models

`covariates` the matrix of covariates common to every models

`offsets` the matrix of offsets common to every models

`weights` the vector of observation weights

`control` a list for controlling the optimization. See details.

Returns: A new `PLNfamily` object

Method `postTreatment()`**:** Update fields after optimization

Usage:

```
PLNfamily$postTreatment()
```

Method `getModel()`**:** Extract a model from a collection of models

Usage:

```
PLNfamily$getModel(var, index = NULL)
```

Arguments:

`var` value of the parameter (`rank` for PLNPCA, `sparsity` for PLNnetwork) that identifies the model to be extracted from the collection. If no exact match is found, the model with closest parameter value is returned with a warning.

`index` Integer index of the model to be returned. Only the first value is taken into account.

Returns: A `PLNfit` object

Method `plot()`**:** Lineplot of selected criteria for all models in the collection

Usage:

```
PLNfamily$plot(criteria, annotate = TRUE)
```

Arguments:

`criteria` A valid model selection criteria for the collection of models. Includes loglik, BIC (all), ICL (PLNPCA) and pen_loglik, EBIC (PLNnetwork)

`annotate` Logical. Should R2 be added to the plot (defaults to `TRUE`)

Returns: A `ggplot2` object

Method `show()`**:** User friendly print method

Usage:

```
PLNfamily$show()
```

Method `print()`**:** User friendly print method

Usage:

```
PLNfamily$print()
```

Method `clone()`**:** The objects of this class are cloneable with this method.

Usage:

```
PLNfamily$clone(deep = FALSE)
```

Arguments:

`deep` Whether to make a deep clone.

See Also

`getModel()`

`PLNfit` *An R6 Class to represent a PLNfit in a standard, general framework*

Description

The function `PLN()` fit a model which is an instance of a object with class `PLNfit`. Objects produced by the functions `PLNnetwork()`, `PLNPCA()` and `PLNLDA()` also enjoy the methods of `PLNfit()` by inheritance.

This class comes with a set of R6 methods, some of them being useful for the user and exported as S3 methods. See the documentation for `coef()`, `sigma()`, `predict()`, `vcov()` and `standard_error()`.

Fields are accessed via active binding and cannot be changed by the user.

Details

The parameter `control` is a list controlling the optimization with the following entries:

- "covariance" character setting the model for the covariance matrix. Either "full", "diagonal" or "spherical". Default is "full".
- "trace" integer for verbosity.
- "inception" Set up the initialization. By default, the model is initialized with a multivariate linear model applied on log-transformed data, and with the same formula as the one provided by the user. However, the user can provide a PLNfit (typically obtained from a previous fit), which sometimes speeds up the inference.
- "ftol_rel" stop when an optimization step changes the objective function by less than ftol multiplied by the absolute value of the parameter. Default is 1e-6 when n < p, 1e-8 otherwise.
- "ftol_abs" stop when an optimization step changes the objective function by less than ftol multiplied by the absolute value of the parameter. Default is 0
- "xtol_rel" stop when an optimization step changes every parameters by less than xtol multiplied by the absolute value of the parameter. Default is 1e-4
- "xtol_abs" stop when an optimization step changes every parameters by less than xtol multiplied by the absolute value of the parameter. Default is 0
- "maxeval" stop when the number of iteration exceeds maxeval. Default is 10000
- "maxtime" stop when the optimization time (in seconds) exceeds maxtime. Default is -1 (no restriction)
- "algorithm" the optimization method used by NLOPT among LD type, i.e. "CCSAQ", "MMA", "LBFGS", "VAR1", "VAR2". See NLOPT documentation for further details. Default is "CCSAQ".

Active bindings

`n` number of samples

`q` number of dimensions of the latent space

`p` number of species

`d` number of covariates

`model_par` a list with the matrices of parameters found in the model (Theta, Sigma, plus some others depending on the variant)

`fisher` Variational approximation of the Fisher Information matrix

`std_err` Variational approximation of the variance-covariance matrix of model parameters estimates.

`var_par` a list with two matrices, M and S2, which are the estimated parameters in the variational approximation

`latent` a matrix: values of the latent vector (Z in the model)

`fitted` a matrix: fitted values of the observations (A in the model)

`nb_param` number of parameters in the current PLN model

`vcov_model` character: the model used for the covariance (either "spherical", "diagonal" or "full")

`optim_par` a list with parameters useful for monitoring the optimization

`loglik` (weighted) variational lower bound of the loglikelihood

`loglik_vec` element-wise variational lower bound of the loglikelihood

`BIC` variational lower bound of the BIC

`entropy` Entropy of the variational distribution

`ICL` variational lower bound of the ICL

`R_squared` approximated goodness-of-fit criterion

`criteria` a vector with loglik, BIC, ICL, R_squared and number of parameters

Methods

Public methods:

- `PLNfit$update()`
- `PLNfit$new()`
- `PLNfit$optimize()`
- `PLNfit$VEstep()`
- `PLNfit$set_R2()`
- `PLNfit$compute_fisher()`
- `PLNfit$compute_standard_error()`
- `PLNfit$postTreatment()`
- `PLNfit$latent_pos()`
- `PLNfit$predict()`
- `PLNfit$show()`
- `PLNfit$print()`
- `PLNfit$clone()`

Method `update()`**:** Update a `PLNfit` object

Usage:

```
PLNfit$update(
  Theta = NA,
  Sigma = NA,
  M = NA,
  S2 = NA,
  Ji = NA,
  R2 = NA,
  Z = NA,
  A = NA,
  monitoring = NA
)
```

Arguments:

`Theta` matrix of regression matrix

`Sigma` variance-covariance matrix of the latent variables

`M` matrix of mean vectors for the variational approximation

`S2` matrix of variance vectors for the variational approximation

`Ji` vector of variational lower bounds of the log-likelihoods (one value per sample)

`R2` approximate R^2 goodness-of-fit criterion

`Z` matrix of latent vectors (includes covariates and offset effects)

`A` matrix of fitted values

`monitoring` a list with optimization monitoring quantities

Returns: Update the current `PLNfit` object

Method `new()`**:** Initialize a `PLNfit` model

Usage:

```
PLNfit$new(responses, covariates, offsets, weights, model, xlevels, control)
```

Arguments:

`responses` the matrix of responses (called Y in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`covariates` design matrix (called X in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`offsets` offset matrix (called O in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`weights` an optional vector of observation weights to be used in the fitting process.

`model` model used for fitting, extracted from the formula in the upper-level call

`xlevels` named listed of factor levels included in the models, extracted from the formula in the upper-level call and used for predictions.

`control` a list for controlling the optimization. See details.

Method `optimize()`**:** Call to the C++ optimizer and update of the relevant fields

Usage:

```
PLNfit$optimize(responses, covariates, offsets, weights, control)
```

Arguments:

`responses` the matrix of responses (called Y in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`covariates` design matrix (called X in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`offsets` offset matrix (called O in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`weights` an optional vector of observation weights to be used in the fitting process.

`control` a list for controlling the optimization. See details.

Method `VEstep()`**:** Result of one call to the VE step of the optimization procedure: optimal variational parameters (M, S) and corresponding log likelihood values for fixed model parameters (Sigma, Theta). Intended to position new data in the latent space.

Usage:

```
PLNfit$VEstep(covariates, offsets, responses, weights, control = list())
```

Arguments:

`covariates` design matrix (called X in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`offsets` offset matrix (called O in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`responses` the matrix of responses (called Y in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`weights` an optional vector of observation weights to be used in the fitting process.

`control` a list for controlling the optimization. See details.

Returns: A list with three components:

- the matrix `M` of variational means,
- the matrix `S` of variational variances
- the vector `log.lik` of (variational) log-likelihood of each new observation

Method `set_R2()`**:** Update R2 field after optimization

Usage:

```
PLNfit$set_R2(responses, covariates, offsets, weights, nullModel = NULL)
```

Arguments:

`responses` the matrix of responses (called Y in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`covariates` design matrix (called X in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`offsets` offset matrix (called O in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`weights` an optional vector of observation weights to be used in the fitting process.

`nullModel` null model used for approximate R2 computations. Defaults to a GLM model with same design matrix but not latent variable.

Method `compute_fisher()`**:** Safely compute the fisher information matrix (FIM)

Usage:

```
PLNfit$compute_fisher(type = c("wald", "louis"), X = NULL)
```

Arguments:

`type` approximation scheme to compute the fisher information matrix. Either `wald` (default) or `louis`. `type = "louis"` results in smaller confidence intervals.

`X` design matrix used to compute the FIM

Returns: a sparse matrix with sensible dimension names

Method `compute_standard_error()`**:** Compute univariate standard error for coefficients of Theta from the FIM

Usage:

```
PLNfit$compute_standard_error()
```

Returns: a matrix of standard deviations.

Method `postTreatment()`**:** Update R2, fisher and std_err fields after optimization

Usage:

```
PLNfit$postTreatment(
  responses,
  covariates,
  offsets,
  weights = rep(1, nrow(responses)),
  type = c("wald", "louis"),
  nullModel = NULL
)
```

Arguments:

`responses` the matrix of responses (called Y in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`covariates` design matrix (called X in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`offsets` offset matrix (called O in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`weights` an optional vector of observation weights to be used in the fitting process.

`type` approximation scheme to compute the fisher information matrix. Either `wald` (default) or `louis`. `type = "louis"` results in smaller confidence intervals.

`nullModel` null model used for approximate R2 computations. Defaults to a GLM model with same design matrix but not latent variable.

Method `latent_pos()`**:** Compute matrix of latent positions, noted as Z in the model. Used to compute the likelihood or for data visualization

Usage:

```
PLNfit$latent_pos(covariates, offsets)
```

Arguments:

`covariates` design matrix (called X in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`offsets` offset matrix (called O in the model). Will usually be extracted from the corresponding field in PLNfamily-class

Returns: a n x q matrix of latent positions.

Method `predict()`**:** Predict position, scores or observations of new data.

Usage:

```
PLNfit$predict(newdata, type = c("link", "response"), envir = parent.frame())
```

Arguments:

`newdata` A data frame in which to look for variables with which to predict. If omitted, the fitted values are used.

`type` Scale used for the prediction. Either `link` (default, predicted positions in the latent space) or `response` (predicted counts).

`envir` Environment in which the prediction is evaluated

Returns: A matrix with predictions scores or counts.

Method `show()`**:** User friendly print method

Usage:

```
PLNfit$show(
  model = paste("A multivariate Poisson Lognormal fit with", private$covariance,
     "covariance model.\n")
)
```

Arguments:

`model` First line of the print output

Method `print()`**:** User friendly print method

Usage:

```
PLNfit$print()
```

Method `clone()`**:** The objects of this class are cloneable with this method.

Usage:

```
PLNfit$clone(deep = FALSE)
```

Arguments:

`deep` Whether to make a deep clone.

Examples

```
## Not run:
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPLN <- PLN(Abundance ~ 1, data = trichoptera)
class(myPLN)
print(myPLN)

## End(Not run)
```

`PLNLDA` *Poisson lognormal model towards Linear Discriminant Analysis*

Description

Fit the Poisson lognormal for LDA with a variational algorithm. Use the (g)lm syntax for model specification (covariates, offsets).

Usage

```
PLNLDA(formula, data, subset, weights, grouping, control = list())
```

Arguments

formula	an object of class "formula": a symbolic description of the model to be fitted.
data	an optional data frame, list or environment (or object coercible by as.data.frame to a data frame) containing the variables in the model. If not found in data, the variables are taken from environment(formula), typically the environment from which lm is called.
subset	an optional vector specifying a subset of observations to be used in the fitting process.
weights	an optional vector of observation weights to be used in the fitting process.
grouping	a factor specifying the class of each observation used for discriminant analysis.
control	a list for controlling the optimization process. See details.

Details

The parameter control is a list controlling the optimization with the following entries:

- "covariance" character setting the model for the covariance matrix. Either "full" or "spherical". Default is "full".
- "trace" integer for verbosity.
- "inception" Set up the initialization. By default, the model is initialized with a multivariate linear model applied on log-transformed data. However, the user can provide a PLNfit (typically obtained from a previous fit), which often speed up the inference.
- "ftol_rel" stop when an optimization step changes the objective function by less than ftol multiplied by the absolute value of the parameter. Default is 1e-8
- "ftol_abs" stop when an optimization step changes the objective function by less than ftol multiplied by the absolute value of the parameter. Default is 0
- "xtol_rel" stop when an optimization step changes every parameters by less than xtol multiplied by the absolute value of the parameter. Default is 1e-4
- "xtol_abs" stop when an optimization step changes every parameters by less than xtol multiplied by the absolute value of the parameter. Default is 0
- "maxeval" stop when the number of iteration exceeds maxeval. Default is 10000
- "maxtime" stop when the optimization time (in seconds) exceeds maxtime. Default is -1 (no restriction)
- "algorithm" the optimization method used by NLOPT among LD type, i.e. "CCSAQ", "MMA", "LBFGS", "VAR1", "VAR2". See NLOPT documentation for further details. Default is "CCSAQ".

Value

an R6 object with class PLNLDAfit()

See Also

The class PLNLDAfit

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPLNLDA <- PLNLDA(Abundance ~ 1, grouping = Group, data = trichoptera)
```

PLNLDAfit *An R6 Class to represent a PLNfit in a LDA framework*

Description

The function PLNLDA() produces an instance of an object with class PLNLDAfit.

This class comes with a set of methods, some of them being useful for the user: See the documentation for the methods inherited by PLNfit(), the plot() method for LDA visualization and predict() method for prediction

Super class

PLNmodels::PLNfit -> PLNLDAfit

Active bindings

rank the dimension of the current model

nb_param number of parameters in the current PLN model

model_par a list with the matrices associated with the estimated parameters of the PLN model: Theta (covariates), Sigma (latent covariance), B (latent loadings), P (latent position) and Mu (group means)

percent_var the percent of variance explained by each axis

corr_map a matrix of correlations to plot the correlation circles

scores a matrix of scores to plot the individual factor maps

group_means a matrix of group mean vectors in the latent space.

Methods

Public methods:

- PLNLDAfit$new()
- PLNLDAfit$optimize()
- PLNLDAfit$postTreatment()
- PLNLDAfit$setVisualization()
- PLNLDAfit$plot_individual_map()
- PLNLDAfit$plot_correlation_map()
- PLNLDAfit$plot_LDA()
- PLNLDAfit$predict()
- PLNLDAfit$show()

- PLNLDAfit$clone()

Method `new()`: Initialize a `PLNLDAfit` object

Usage:

```
PLNLDAfit$new(
  grouping,
  responses,
  covariates,
  offsets,
  weights,
  model,
  xlevels,
  control
)
```

Arguments:

`grouping` a factor specifying the class of each observation used for discriminant analysis.

`responses` the matrix of responses (called Y in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`covariates` design matrix (called X in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`offsets` offset matrix (called O in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`weights` an optional vector of observation weights to be used in the fitting process.

`model` model used for fitting, extracted from the formula in the upper-level call

`xlevels` named listed of factor levels included in the models, extracted from the formula in the upper-level call and used for predictions.

`control` a list for controlling the optimization. See details.

Method `optimize()`: Compute group means and axis of the LDA (noted B in the model) in the latent space, update corresponding fields

Usage:

```
PLNLDAfit$optimize(X, covar, design_group, control)
```

Arguments:

`X` Abundance matrix.

`covar` design matrix. Automatically built from the covariates and the formula from the call

`design_group` design matrix for the grouping variable

`control` a list for controlling the optimization. See details.

Method `postTreatment()`: Update R2, fisher and std_err fields and visualization after optimization

Usage:

```
PLNLDAfit$postTreatment(responses, covariates, offsets)
```

Arguments:

`responses` the matrix of responses (called Y in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`covariates` design matrix (called X in the model). Will usually be extracted from the corresponding field in PLNfamily-class

`offsets` offset matrix (called O in the model). Will usually be extracted from the corresponding field in PLNfamily-class

Method `setVisualization()`**:** Compute LDA scores in the latent space and update corresponding fields.

Usage:

```
PLNLDAfit$setVisualization(scale.unit = FALSE)
```

Arguments:

`scale.unit` Logical. Should LDA scores be rescaled to have unit variance

Method `plot_individual_map()`**:** Plot the factorial map of the LDA

Usage:

```
PLNLDAfit$plot_individual_map(
  axes = 1:min(2, self$rank),
  main = "Individual Factor Map",
  plot = TRUE
)
```

Arguments:

`axes` numeric, the axes to use for the plot when map = "individual" or "variable". Default it c(1,min(rank))

`main` character. A title for the single plot (individual or variable factor map). If NULL (the default), an hopefully appropriate title will be used.

`plot` logical. Should the plot be displayed or sent back as ggplot object

Returns: a `ggplot` graphic

Method `plot_correlation_map()`**:** Plot the correlation circle of a specified axis for a `PLNLDAfit` object

Usage:

```
PLNLDAfit$plot_correlation_map(
  axes = 1:min(2, self$rank),
  main = "Variable Factor Map",
  cols = "default",
  plot = TRUE
)
```

Arguments:

`axes` numeric, the axes to use for the plot when map = "individual" or "variable". Default it c(1,min(rank))

`main` character. A title for the single plot (individual or variable factor map). If NULL (the default), an hopefully appropriate title will be used.

`cols` a character, factor or numeric to define the color associated with the variables. By default, all variables receive the default color of the current palette.

`plot` logical. Should the plot be displayed or sent back as ggplot object

Returns: a ggplot graphic

Method `plot_LDA()`**:** Plot a summary of the PLNLDAfit object

Usage:

```
PLNLDAfit$plot_LDA(
  nb_axes = min(3, self$rank),
  var_cols = "default",
  plot = TRUE
)
```

Arguments:

`nb_axes` scalar: the number of axes to be considered when map = "both". The default is min(3,rank).

`var_cols` a character, factor or numeric to define the color associated with the variables. By default, all variables receive the default color of the current palette.

`plot` logical. Should the plot be displayed or sent back as ggplot object

Returns: a grob object

Method `predict()`**:** Predict group of new samples

Usage:

```
PLNLDAfit$predict(
  newdata,
  type = c("posterior", "response", "scores"),
  scale = c("log", "prob"),
  prior = NULL,
  control = list(),
  envir = parent.frame()
)
```

Arguments:

`newdata` A data frame in which to look for variables, offsets and counts with which to predict.

`type` The type of prediction required. The default are posterior probabilities for each group (in either unnormalized log-scale or natural probabilities, see "scale" for details), "response" is the group with maximal posterior probability and "scores" is the average score along each separation axis in the latent space, with weights equal to the posterior probabilities.

`scale` The scale used for the posterior probability. Either log-scale ("log", default) or natural probabilities summing up to 1 ("prob").

`prior` User-specified prior group probabilities in the new data. If NULL (default), prior probabilities are computed from the learning set.

`control` a list for controlling the optimization. See PLN() for details.

`envir` Environment in which the prediction is evaluated

Method `show()`**:** User friendly print method

Usage:

```
PLNLDAfit$show()
```

Method `clone()`**:** The objects of this class are cloneable with this method.

Usage:

```
PLNLDAfit$clone(deep = FALSE)
```

Arguments:

`deep` Whether to make a deep clone.

See Also

The function `PLNLDA`.

Examples

```
## Not run:
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPLNLDA <- PLNLDA(Abundance ~ 1, grouping = Group, data = trichoptera)
class(myPLNLDA)
print(myPLNLDA)

## End(Not run)
```

`PLNmodels` *PLNmodels*

Description

The Poisson lognormal model and variants can be used for a variety of multivariate problems when count data are at play (including PCA or LDA for count data, network inference). This package implements efficient variational algorithms to fit such models accompanied with a set of functions for visualization and diagnostic.

Multivariate Poisson lognormal model (aka PLN)

See the main function `PLN()` and the associated methods for manipulation.

Also try vignette("PLN_trichoptera", package="PLNmodels") for an overview.

Rank Constrained Poisson lognormal for Poisson Principal Component Analysis (aka PLNPCA)

See the main function `PLNPCA()` and the associated methods for manipulation.

The Poisson PCA and the associated variational inference is fully explained in Chiquet el al (2018), see reference below.

Also try vignette("PLNPCA_trichoptera", package="PLNmodels") for an overview.

Sparse Poisson lognormal model for sparse covariance inference for counts (aka PLNnetwork)

See the main function `PLNnetwork()` and the associated methods for manipulation.

Also try vignette("PLNnetwork_trichoptera", package="PLNmodels") for an overview.

Poisson lognormal discriminant analysis (aka PLNLDA)

See the main function `PLNLDA()` and the associated methods for manipulation.

Also try vignette("PLNLDA_trichoptera", package="PLNmodels") for an overview.

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PLNnetwork *Poisson lognormal model towards sparse network inference*

Description

Fit the sparse inverse covariance variant of the Poisson lognormal with a variational algorithm. Use the (g)lm syntax for model specification (covariates, offsets).

Usage

```
PLNnetwork(
  formula,
  data,
  subset,
  weights,
  penalties = NULL,
  control_init = list(),
  control_main = list()
)
```

Arguments

`formula`	an object of class "formula": a symbolic description of the model to be fitted.
`data`	an optional data frame, list or environment (or object coercible by as.data.frame to a data frame) containing the variables in the model. If not found in data, the variables are taken from environment(formula), typically the environment from which lm is called.
`subset`	an optional vector specifying a subset of observations to be used in the fitting process.
`weights`	an optional vector of observation weights to be used in the fitting process.
`penalties`	an optional vector of positive real number controlling the level of sparsity of the underlying network. if NULL (the default), will be set internally. See `control_init` and `control_main` options for additional tuning of the penalty.
`control_init`	a list for controlling the optimization of the PLN model used at initialization, and how the vector of `penalties` is generated. See details.

`control_main` a list for controlling the main optimization process. Can be used to specify adaptive penalty weights. See details.

Details

The list of parameters `control_main` controls the optimization of the main process, with the following entries:

- "ftol_rel" stop when an optimization step changes the objective function by less than ftol multiplied by the absolute value of the parameter. Default is 1e-6 when n < p, 1e-8 otherwise.
- "ftol_abs" stop when an optimization step changes the objective function by less than ftol multiplied by the absolute value of the parameter. Default is 0
- "xtol_rel" stop when an optimization step changes every parameters by less than xtol_rel multiplied by the absolute value of the parameter. Default is 1e-4
- "xtol_abs" stop when an optimization step changes every parameters by less than xtol_abs. Default is 0
- "maxeval" stop when the number of iteration exceeds maxeval. Default is 10000
- "algorithm" the optimization method used by NLOPT among LD type, i.e. "CCSAQ", "MMA", "LBFGS", "VAR1", "VAR2". See NLOPT documentation for further details. Default is "CCSAQ".
- "cores" integer for number of cores used. Default is 1.
- "trace" integer for verbosity. Useless when `cores` > 1
- "ftol_out" outer solver stops when an optimization step changes the objective function by less than xtol multiply by the absolute value of the parameter. Default is 1e-6
- "maxit_out" outer solver stops when the number of iteration exceeds out.maxit. Default is 50
- "penalize_diagonal" boolean: should the diagonal terms be penalized in the graphical-Lasso? Default is FALSE.
- "penalty_weights" p x p matrix of weights (default filled with 1) to adapt the amount of shrinkage to each pairs of node. Must be symmetric with positive values.

The list of parameters `control_init` controls the optimization process in the initialization and in the function `PLN()`, plus two additional parameters:

- "nPenalties" an integer that specified the number of values for the penalty grid when internally generated. Ignored when penalties is non `NULL`
- "min.ratio" the penalty grid ranges from the minimal value that produces a sparse to this value multiplied by `min.ratio`. Default is 0.1.

Value

an R6 object with class `PLNnetworkfamily`, which contains a collection of models with class `PLNnetworkfit`

See Also

The classes `PLNnetworkfamily` and `PLNnetworkfit`

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
fits <- PLNnetwork(Abundance ~ 1, data = trichoptera)
```

`PLNnetworkfamily` *An R6 Class to represent a collection of PLNnetworkfit*

Description

The function `PLNnetwork()` produces an instance of this class.

This class comes with a set of methods, some of them being useful for the user: See the documentation for `getBestModel()`, `getModel()` and plot()

Super class

`PLNmodels::PLNfamily` -> `PLNnetworkfamily`

Active bindings

`penalties` the sparsity level of the network in the successively fitted models

`stability_path` the stability path of each edge as returned by the stars procedure

`stability` mean edge stability along the penalty path

`criteria` a data frame with the values of some criteria (variational lower bound J, BIC, ICL and R2, stability) for the collection of models / fits

Methods

Public methods:

- `PLNnetworkfamily$new()`
- `PLNnetworkfamily$optimize()`
- `PLNnetworkfamily$stability_selection()`
- `PLNnetworkfamily$coefficient_path()`
- `PLNnetworkfamily$getBestModel()`
- `PLNnetworkfamily$plot()`
- `PLNnetworkfamily$plot_stars()`
- `PLNnetworkfamily$plot_objective()`
- `PLNnetworkfamily$show()`
- `PLNnetworkfamily$clone()`

Method `new()`**:** Initialize all models in the collection

Usage:

```
PLNnetworkfamily$new(
  penalties,
  responses,
  covariates,
  offsets,
  weights,
  model,
  xlevels,
  control
)
```

Arguments:

`penalties` a vector of positive real number controlling the level of sparsity of the underlying network.

`responses` the matrix of responses common to every models

`covariates` the matrix of covariates common to every models

`offsets` the matrix of offsets common to every models

`weights` the vector of observation weights

`model` model used for fitting, extracted from the formula in the upper-level call

`xlevels` named listed of factor levels included in the models, extracted from the formula in the upper-level call and used for predictions.

`control` a list for controlling the optimization. See details.

Returns: Update current `PLNnetworkfit` with smart starting values

Method `optimize()`**:** Call to the C++ optimizer on all models of the collection

Usage:

```
PLNnetworkfamily$optimize(control)
```

Arguments:

`control` a list for controlling the optimization. See details.

Method `stability_selection()`**:** Compute the stability path by stability selection

Usage:

```
PLNnetworkfamily$stability_selection(
  subsamples = NULL,
  control = list(),
  mc.cores = 1
)
```

Arguments:

`subsamples` a list of vectors describing the subsamples. The number of vectors (or list length) determines th number of subsamples used in the stability selection. Automatically set to 20 subsamples with size `10*sqrt(n)` if `n >= 144` and `0.8*n` otherwise following Liu et al. (2010) recommendations.

`control` a list controlling the main optimization process in each call to PLNnetwork. See `PLNnetwork()` for details.

`mc.cores` the number of cores to used. Default is 1.

Method `coefficient_path()`**:** Extract the regularization path of a `PLNnetworkfamily`

Usage:

```
PLNnetworkfamily$coefficient_path(precision = TRUE, corr = TRUE)
```

Arguments:

`precision` Logical. Should the regularization path be extracted from the precision matrix Omega (`TRUE`, default) or from the variance matrix Sigma (`FALSE`)

`corr` Logical. Should the matrix be transformed to (partial) correlation matrix before extraction? Defaults to `TRUE`

Method `getBestModel()`**:** Extract the best network in the family according to some criteria

Usage:

```
PLNnetworkfamily$getBestModel(
  crit = c("BIC", "loglik", "R_squared", "EBIC", "StARS"),
  stability = 0.9
)
```

Arguments:

`crit` character. Criterion used to perform the selection. Is "StARS" is chosen but $stability field is empty, will compute stability path.

`stability` Only used for "StARS" criterion. A scalar indicating the target stability (= 1 - 2 beta) at which the network is selected. Default is `0.9`.

Method `plot()`**:** Display various outputs (goodness-of-fit criteria, robustness, diagnostic) associated with a collection of PLNnetwork fits (a `PLNnetworkfamily`)

Usage:

```
PLNnetworkfamily$plot(
  criteria = c("loglik", "pen_loglik", "BIC", "EBIC"),
  log.x = TRUE,
  annotate
)
```

Arguments:

`criteria` vector of characters. The criteria to plot in `c("loglik","pen_loglik","BIC","EBIC")`. Defaults to all of them.

`log.x` logical: should the x-axis be represented in log-scale? Default is `TRUE`.

`annotate` logical: should the value of approximated R squared be added to the plot of criteria? Default is `TRUE`.

Returns: a `ggplot` graph

Method `plot_stars()`**:** Plot stability path

Usage:

```
PLNnetworkfamily$plot_stars(stability = 0.9, log.x = TRUE)
```

Arguments:

`stability` scalar: the targeted level of stability in stability plot. Default is `0.9`.

`log.x` logical: should the x-axis be represented in log-scale? Default is `TRUE`.

Returns: a ggplot graph

Method `plot_objective()`**:** Plot objective value of the optimization problem along the penalty path

Usage:

```
PLNnetworkfamily$plot_objective()
```

Returns: a ggplot graph

Method `show()`**:** User friendly print method

Usage:

```
PLNnetworkfamily$show()
```

Method `clone()`**:** The objects of this class are cloneable with this method.

Usage:

```
PLNnetworkfamily$clone(deep = FALSE)
```

Arguments:

`deep` Whether to make a deep clone.

See Also

The function `PLNnetwork()`, the class `PLNnetworkfit`

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
fits <- PLNnetwork(Abundance ~ 1, data = trichoptera)
class(fits)
```

`PLNnetworkfit` *An R6 Class to represent a PLNfit in a sparse inverse covariance framework*

Description

The function `PLNnetwork()` produces a collection of models which are instances of object with class `PLNnetworkfit`.

This class comes with a set of methods, some of them being useful for the user: See the documentation for `plot()` and methods inherited from `PLNfit`.

Super class

`PLNmodels::PLNfit` -> `PLNnetworkfit`

Active bindings

`penalty` the level of sparsity in the current model

`n_edges` number of edges if the network (non null coefficient of the sparse precision matrix)

`nb_param` number of parameters in the current PLN model

`pen_loglik` variational lower bound of the l1-penalized loglikelihood

`model_par` a list with the matrices associated with the estimated parameters of the pPCA model: Theta (covariates), Sigma (latent covariance) and Theta (latent precision matrix). Note Omega and Sigma are inverse of each other.

`EBIC` variational lower bound of the EBIC

`density` proportion of non-null edges in the network

`criteria` a vector with loglik, penalized loglik, BIC, EBIC, ICL, R_squared, number of parameters, number of edges, and graph density

Methods

Public methods:

- `PLNnetworkfit$new()`
- `PLNnetworkfit$update()`
- `PLNnetworkfit$optimize()`
- `PLNnetworkfit$postTreatment()`
- `PLNnetworkfit$latent_network()`
- `PLNnetworkfit$plot_network()`
- `PLNnetworkfit$show()`
- `PLNnetworkfit$clone()`

Method `new()`**:** Initialize a `PLNnetworkfit` object

Usage:

```
PLNnetworkfit$new(
  penalty,
  responses,
  covariates,
  offsets,
  weights,
  model,
  xlevels,
  control
)
```

Arguments:

`penalty` a positive real number controlling the level of sparsity of the underlying network.

`responses` the matrix of responses common to every models

`covariates` the matrix of covariates common to every models

`offsets` the matrix of offsets common to every models

`weights` an optional vector of observation weights to be used in the fitting process.

`model` model used for fitting, extracted from the formula in the upper-level call

`xlevels` named listed of factor levels included in the models, extracted from the formula in `PLNnetwork()` call

`control` a list for controlling the optimization of the PLN model used at initialization. See `PLNnetwork()` for details.

Method `update()`**:** Update fields of a `PLNnetworkfit` object

Usage:

```
PLNnetworkfit$update(
  penalty = NA,
  Theta = NA,
  Sigma = NA,
  Omega = NA,
  M = NA,
  S2 = NA,
  Z = NA,
  A = NA,
  Ji = NA,
  R2 = NA,
  monitoring = NA
)
```

Arguments:

`penalty` a positive real number controlling the level of sparsity of the underlying network.

`Theta` matrix of regression matrix

`Sigma` variance-covariance matrix of the latent variables

`Omega` precision matrix of the latent variables. Inverse of Sigma.

`M` matrix of mean vectors for the variational approximation

`S2` matrix of variance vectors for the variational approximation

`Z` matrix of latent vectors (includes covariates and offset effects)

`A` matrix of fitted values

`Ji` vector of variational lower bounds of the log-likelihoods (one value per sample)

`R2` approximate R^2 goodness-of-fit criterion

`monitoring` a list with optimization monitoring quantities

Method `optimize()`**:** Call to the C++ optimizer and update of the relevant fields

Usage:

```
PLNnetworkfit$optimize(responses, covariates, offsets, weights, control)
```

Arguments:

`responses` the matrix of responses common to every models

`covariates` the matrix of covariates common to every models

`offsets` the matrix of offsets common to every models

`weights` an optional vector of observation weights to be used in the fitting process.

`control` a list for controlling the optimization of the PLN model used at initialization. See `PLNnetwork()` for details.

Method `postTreatment()`**:** Compute PCA scores in the latent space and update corresponding fields.

Usage:

```
PLNnetworkfit$postTreatment(responses, covariates, offsets, weights, nullModel)
```

Arguments:

`responses` the matrix of responses common to every models

`covariates` the matrix of covariates common to every models

`offsets` the matrix of offsets common to every models

`weights` an optional vector of observation weights to be used in the fitting process.

`nullModel` null model used for approximate R2 computations. Defaults to a GLM model with same design matrix but not latent variable.

Method `latent_network()`**:** Extract interaction network in the latent space

Usage:

```
PLNnetworkfit$latent_network(type = c("partial_cor", "support", "precision"))
```

Arguments:

`type` edge value in the network. Can be "support" (binary edges), "precision" (coefficient of the precision matrix) or "partial_cor" (partial correlation between species)

Returns: a square matrix of size `PLNnetworkfit$n`

Method `plot_network()`**:** plot the latent network.

Usage:

```
PLNnetworkfit$plot_network(
  type = c("partial_cor", "support"),
  output = c("igraph", "corrplot"),
  edge.color = c("#F8766D", "#00BFC4"),
  remove.isolated = FALSE,
  node.labels = NULL,
  layout = layout_in_circle,
  plot = TRUE
)
```

Arguments:

`type` edge value in the network. Either "precision" (coefficient of the precision matrix) or "partial_cor" (partial correlation between species).

`output` Output type. Either `igraph` (for the network) or `corrplot` (for the adjacency matrix)

`edge.color` Length 2 color vector. Color for positive/negative edges. Default is `c("#F8766D","#00BFC4")`. Only relevant for igraph output.

`remove.isolated` if `TRUE`, isolated node are remove before plotting. Only relevant for igraph output.

`node.labels` vector of character. The labels of the nodes. The default will use the column names ot the response matrix.

`layout` an optional igraph layout. Only relevant for igraph output.

`plot` logical. Should the final network be displayed or only sent back to the user. Default is `TRUE`.

Method `show()`**:** User friendly print method

Usage:

```
PLNnetworkfit$show()
```

Method `clone()`**:** The objects of this class are cloneable with this method.

Usage:

```
PLNnetworkfit$clone(deep = FALSE)
```

Arguments:

`deep` Whether to make a deep clone.

See Also

The function `PLNnetwork()`, the class `PLNnetworkfamily`

Examples

```
## Not run:
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
nets <- PLNnetwork(Abundance ~ 1, data = trichoptera)
myPLNnet <- getBestModel(nets)
class(myPLNnet)
print(myPLNnet)

## End(Not run)
```

PLNPCA *Poisson lognormal model towards Principal Component Analysis*

Description

Fit the PCA variants of the Poisson lognormal with a variational algorithm. Use the (g)lm syntax for model specification (covariates, offsets).

Usage

```
PLNPCA(
  formula,
  data,
  subset,
  weights,
  ranks = 1:5,
  control_init = list(),
  control_main = list()
)
```

Arguments

formula	an object of class "formula": a symbolic description of the model to be fitted.
data	an optional data frame, list or environment (or object coercible by as.data.frame to a data frame) containing the variables in the model. If not found in data, the variables are taken from environment(formula), typically the environment from which lm is called.
subset	an optional vector specifying a subset of observations to be used in the fitting process.
weights	an optional vector of observation weights to be used in the fitting process.
ranks	a vector of integer containing the successive ranks (or number of axes to be considered)
control_init	a list for controlling the optimization at initialization. See details of function PLN().
control_main	a list for controlling the main optimization process. See details.

Details

The list of parameters control_main controls the optimization of the main process, with the following entries:

- "ftol_rel" stop when an optimization step changes the objective function by less than ftol multiplied by the absolute value of the parameter. Default is 1e-8
- "ftol_abs" stop when an optimization step changes the objective function by less than ftol multiplied by the absolute value of the parameter. Default is 0
- "xtol_rel" stop when an optimization step changes every parameters by less than xtol multiplied by the absolute value of the parameter. Default is 1e-4
- "xtol_abs" stop when an optimization step changes every parameters by less than xtol multiplied by the absolute value of the parameter. Default is 0
- "maxeval" stop when the number of iteration exceeds maxeval. Default is 10000
- "maxtime" stop when the optimization time (in seconds) exceeds maxtime. Default is -1 (no restriction)
- "algorithm" the optimization method used by NLOPT among LD type, i.e. "CCSAQ", "MMA", "LBFGS", "VAR1", "VAR2". See NLOPT documentation for further details. Default is "CCSAQ".
- "trace" integer for verbosity. Useless when cores > 1
- "cores" The number of core used to parallelize jobs over the ranks vector. Default is 1.

Value

an R6 object with class PLNPCAfamily, which contains a collection of models with class PLNPCAfit

See Also

The classes PLNPCAfamily and PLNPCAfit

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPCA <- PLNPCA(Abundance ~ 1 + offset(log(Offset)), data = trichoptera, ranks = 1:5)
```

PLNPCAfamily *An R6 Class to represent a collection of PLNPCAfit*

Description

The function PLNPCA() produces an instance of this class.

This class comes with a set of methods, some of them being useful for the user: See the documentation for getBestModel(), getModel() and plot().

Super class

PLNmodels::PLNfamily -> PLNPCAfamily

Active bindings

ranks the dimensions of the successively fitted models

Methods

Public methods:

- PLNPCAfamily$new()
- PLNPCAfamily$optimize()
- PLNPCAfamily$getBestModel()
- PLNPCAfamily$plot()
- PLNPCAfamily$show()
- PLNPCAfamily$clone()

Method new(): Initialize all models in the collection.

Usage:

```
PLNPCAfamily$new(
  ranks,
  responses,
  covariates,
  offsets,
  weights,
  model,
  xlevels,
  control
)
```

Arguments:

`ranks` the dimensions of the successively fitted models

`responses` the matrix of responses common to every models

`covariates` the matrix of covariates common to every models

`offsets` the matrix of offsets common to every models

`weights` the vector of observation weights

`model` model used for fitting, extracted from the formula in the upper-level call

`xlevels` named listed of factor levels included in the models, extracted from the formula in the upper-level call and used for predictions.

`control` a list for controlling the optimization. See details.

Method `optimize()`**:** Call to the C++ optimizer on all models of the collection

Usage:

```
PLNPCAfamily$optimize(control)
```

Arguments:

`control` a list for controlling the optimization. See details.

Method `getBestModel()`**:** Extract best model in the collection

Usage:

```
PLNPCAfamily$getBestModel(crit = c("BIC", "ICL", "R_squared"))
```

Arguments:

`crit` a character for the criterion used to performed the selection. Either "BIC", "ICL", or "R_squared". Default is `BIC`

Returns: a `PLNPCAfit` object

Method `plot()`**:** Lineplot of selected criteria for all models in the collection

Usage:

```
PLNPCAfamily$plot(criteria = c("loglik", "BIC", "ICL"), annotate = TRUE)
```

Arguments:

`criteria` A valid model selection criteria for the collection of models. Any of "loglik", "BIC" or "ICL" (all).

`annotate` Logical. Should R2 be added to the plot (defaults to `TRUE`)

Returns: A `ggplot2` object

Method `show()`**:** User friendly print method

Usage:

```
PLNPCAfamily$show()
```

Method `clone()`**:** The objects of this class are cloneable with this method.

Usage:

```
PLNPCAfamily$clone(deep = FALSE)
```

Arguments:

`deep` Whether to make a deep clone.

See Also

The function PLNPCA(), the class PLNPCAfit()

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPCAs <- PLNPCA(Abundance ~ 1 + offset(log(Offset)), data = trichoptera, ranks = 1:5)
class(myPCAs)
```

PLNPCAfit *An R6 Class to represent a PLNfit in a PCA framework*

Description

The function PLNPCA() produces a collection of models which are instances of object with class PLNPCAfit. This class comes with a set of methods, some of them being useful for the user: See the documentation for the methods inherited by PLNfit and the plot() methods for PCA visualization

Super class

PLNmodels::PLNfit -> PLNPCAfit

Active bindings

rank the dimension of the current model

nb_param number of parameters in the current PLN model

entropy entropy of the variational distribution

model_par a list with the matrices associated with the estimated parameters of the pPCA model: Theta (covariates), Sigma (latent covariance) and B (latent loadings)

percent_var the percent of variance explained by each axis

corr_circle a matrix of correlations to plot the correlation circles

scores a matrix of scores to plot the individual factor maps (a.k.a. principal components)

rotation a matrix of rotation of the latent space

Methods

Public methods:

- PLNPCAfit$new()
- PLNPCAfit$update()
- PLNPCAfit$optimize()
- PLNPCAfit$setVisualization()
- PLNPCAfit$postTreatment()
- PLNPCAfit$compute_fisher()

- PLNPCAfit$latent_pos()
- PLNPCAfit$plot_individual_map()
- PLNPCAfit$plot_correlation_circle()
- PLNPCAfit$plot_PCA()
- PLNPCAfit$show()
- PLNPCAfit$clone()

Method `new()`**:** Initialize a `PLNPCAfit` object

Usage:

```
PLNPCAfit$new(
  rank,
  responses,
  covariates,
  offsets,
  weights,
  model,
  xlevels,
  control
)
```

Arguments:

`rank` rank of the PCA (or equivalently, dimension of the latent space)

`responses` the matrix of responses (called Y in the model). Will usually be extracted from the corresponding field in `PLNfamily`

`covariates` design matrix (called X in the model). Will usually be extracted from the corresponding field in `PLNfamily`

`offsets` offset matrix (called O in the model). Will usually be extracted from the corresponding field in `PLNfamily`

`weights` an optional vector of observation weights to be used in the fitting process.

`model` model used for fitting, extracted from the formula in the upper-level call

`xlevels` named listed of factor levels included in the models, extracted from the formula in the upper-level call and used for predictions.

`control` a list for controlling the optimization. See details.

Method `update()`**:** Update a `PLNPCAfit` object

Usage:

```
PLNPCAfit$update(
  Theta = NA,
  Sigma = NA,
  B = NA,
  M = NA,
  S2 = NA,
  Z = NA,
  A = NA,
  Ji = NA,
  R2 = NA,
  monitoring = NA
)
```

Arguments:

`Theta` matrix of regression matrix

`Sigma` variance-covariance matrix of the latent variables

`B` matrix of PCA loadings (in the latent space)

`M` matrix of mean vectors for the variational approximation

`S2` matrix of variance vectors for the variational approximation

`Z` matrix of latent vectors (includes covariates and offset effects)

`A` matrix of fitted values

`Ji` vector of variational lower bounds of the log-likelihoods (one value per sample)

`R2` approximate R^2 goodness-of-fit criterion

`monitoring` a list with optimization monitoring quantities

Returns: Update the current `PLNPCAfit` object

Method `optimize()`**:** Call to the C++ optimizer and update of the relevant fields

Usage:

```
PLNPCAfit$optimize(responses, covariates, offsets, weights, control)
```

Arguments:

`responses` the matrix of responses (called Y in the model). Will usually be extracted from the corresponding field in `PLNfamily`

`covariates` design matrix (called X in the model). Will usually be extracted from the corresponding field in `PLNfamily`

`offsets` offset matrix (called O in the model). Will usually be extracted from the corresponding field in `PLNfamily`

`weights` an optional vector of observation weights to be used in the fitting process.

`control` a list for controlling the optimization. See details.

Method `setVisualization()`**:** Compute PCA scores in the latent space and update corresponding fields.

Usage:

```
PLNPCAfit$setVisualization(scale.unit = FALSE)
```

Arguments:

`scale.unit` Logical. Should PCA scores be rescaled to have unit variance

Method `postTreatment()`**:** Update R2, fisher, std_err fields and set up visualization after optimization

Usage:

```
PLNPCAfit$postTreatment(responses, covariates, offsets, weights, nullModel)
```

Arguments:

`responses` the matrix of responses (called Y in the model). Will usually be extracted from the corresponding field in `PLNfamily`

`covariates` design matrix (called X in the model). Will usually be extracted from the corresponding field in `PLNfamily`

`offsets` offset matrix (called O in the model). Will usually be extracted from the corresponding field in `PLNfamily`

`weights` an optional vector of observation weights to be used in the fitting process.

`nullModel` null model used for approximate R2 computations. Defaults to a GLM model with same design matrix but not latent variable.

Method `compute_fisher()`**:** Safely compute the fisher information matrix (FIM)

Usage:

```
PLNPCAfit$compute_fisher(type = c("wald", "louis"), X = NULL)
```

Arguments:

`type` approximation scheme to compute the fisher information matrix. Either `wald` (default) or `louis`. `type = "louis"` results in smaller confidence intervals.

`X` design matrix used to compute the FIM

Returns: a sparse matrix with sensible dimension names

Method `latent_pos()`**:** Compute matrix of latent positions, noted as Z in the model. Useful to compute the likelihood or for data visualization

Usage:

```
PLNPCAfit$latent_pos(covariates, offsets)
```

Arguments:

`covariates` design matrix (called X in the model). Will usually be extracted from the corresponding field in `PLNfamily`

`offsets` offset matrix (called O in the model). Will usually be extracted from the corresponding field in `PLNfamily`

Returns: a n x q matrix of latent positions.

Method `plot_individual_map()`**:** Plot the factorial map of the PCA

Usage:

```
PLNPCAfit$plot_individual_map(
  axes = 1:min(2, self$rank),
  main = "Individual Factor Map",
  plot = TRUE,
  cols = "default"
)
```

Arguments:

`axes` numeric, the axes to use for the plot when map = "individual" or "variable". Default it c(1,min(rank))

`main` character. A title for the single plot (individual or variable factor map). If NULL (the default), an hopefully appropriate title will be used.

`plot` logical. Should the plot be displayed or sent back as ggplot object

`cols` a character, factor or numeric to define the color associated with the individuals. By default, all individuals receive the default color of the current palette.

Returns: a `ggplot` graphic

Method `plot_correlation_circle()`: Plot the correlation circle of a specified axis for a `PLNLDAfit` object

Usage:

```
PLNPCAfit$plot_correlation_circle(
  axes = 1:min(2, self$rank),
  main = "Variable Factor Map",
  cols = "default",
  plot = TRUE
)
```

Arguments:

`axes` numeric, the axes to use for the plot when map = "individual" or "variable". Default it c(1,min(rank))

`main` character. A title for the single plot (individual or variable factor map). If NULL (the default), an hopefully appropriate title will be used.

`cols` a character, factor or numeric to define the color associated with the variables. By default, all variables receive the default color of the current palette.

`plot` logical. Should the plot be displayed or sent back as ggplot object

Returns: a `ggplot` graphic

Method `plot_PCA()`: Plot a summary of the `PLNPCAfit` object

Usage:

```
PLNPCAfit$plot_PCA(
  nb_axes = min(3, self$rank),
  ind_cols = "ind_cols",
  var_cols = "var_cols",
  plot = TRUE
)
```

Arguments:

`nb_axes` scalar: the number of axes to be considered when map = "both". The default is min(3,rank).

`ind_cols` a character, factor or numeric to define the color associated with the individuals. By default, all variables receive the default color of the current palette.

`var_cols` a character, factor or numeric to define the color associated with the variables. By default, all variables receive the default color of the current palette.

`plot` logical. Should the plot be displayed or sent back as ggplot object

Returns: a `grob` object

Method `show()`: User friendly print method

Usage:

```
PLNPCAfit$show()
```

Method `clone()`: The objects of this class are cloneable with this method.

Usage:

```
PLNPCAfit$clone(deep = FALSE)
```

Arguments:

`deep` Whether to make a deep clone.

See Also

The function PLNPCA, the class PLNPCAfamily

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPCAs <- PLNPCA(Abundance ~ 1 + offset(log(Offset)), data = trichoptera, ranks = 1:5)
myPCA <- getBestModel(myPCAs)
class(myPCA)
print(myPCA)
```

---

plot.PLNLDAfit *LDA visualization (individual and/or variable factor map(s)) for a* PLNPCAfit *object*

Description

LDA visualization (individual and/or variable factor map(s)) for a PLNPCAfit object

Usage

```
## S3 method for class 'PLNLDAfit'
plot(
  x,
  map = c("both", "individual", "variable"),
  nb_axes = min(3, x$rank),
  axes = seq.int(min(2, x$rank)),
  var_cols = "var_colors",
  plot = TRUE,
  main = NULL,
  ...
)
```

Arguments

x	an R6 object with class PLNPCAfit
map	the type of output for the PCA visualization: either "individual", "variable" or "both". Default is "both".
nb_axes	scalar: the number of axes to be considered when map = "both". The default is min(3,rank).
axes	numeric, the axes to use for the plot when map = "individual" or "variable". Default it c(1,min(rank))
var_cols	a character or factor to define the color associated with the variables. By default, all variables receive the default color of the current palette.
plot	logical. Should the plot be displayed or sent back as ggplot2 object

main	character. A title for the single plot (individual or variable factor map). If NULL (the default), an hopefully appropriate title will be used.
...	Not used (S3 compatibility).

Value

displays an individual and/or variable factor maps for the corresponding axes, and/or sends back a ggplot2 or gtable object

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPLNLDA <- PLNLDA(Abundance ~ 1, grouping = Group, data = trichoptera)
## Not run:
plot(myPLNLDA, map = "individual", nb_axes = 2)

## End(Not run)
```

---

plot.PLNnetworkfamily *Display various outputs (goodness-of-fit criteria, robustness, diagnostic) associated with a collection of PLNnetwork fits (a PLNnetworkfamily)*

Description

Display various outputs (goodness-of-fit criteria, robustness, diagnostic) associated with a collection of PLNnetwork fits (a PLNnetworkfamily)

Usage

```
## S3 method for class 'PLNnetworkfamily'
plot(
  x,
  type = c("criteria", "stability", "diagnostic"),
  criteria = c("loglik", "pen_loglik", "BIC", "EBIC"),
  log.x = TRUE,
  stability = 0.9,
  annotate = TRUE,
  ...
)
```

Arguments

x	an R6 object with class PLNnetworkfamily
type	a character, either "criteria", "stability" or "diagnostic" for the type of plot.

criteria	vector of characters. The criteria to plot in c("loglik", "BIC", "ICL", "R_squared", "EBIC", "pen_loglik"). Default is c("loglik", "pen_loglik", "BIC", "EBIC"). Only relevant when type = "criteria".
log.x	logical: should the x-axis be represented in log-scale? Default is TRUE.
stability	scalar: the targeted level of stability in stability plot. Default is .9.
annotate	logical: should the value of approximated R squared be added to the plot of criteria? Default is TRUE.
...	additional parameters for S3 compatibility. Not used

Value

Produces a plot representing the evolution of the criteria of the different models considered, highlighting the best model in terms of BIC and EBIC (the greater, the better). These criteria have the form 'loglik - 1/2 * penalty' so that they are on the same scale as the model loglikelihood.

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
fits <- PLNnetwork(Abundance ~ 1, data = trichoptera)
## Not run:
plot(fits)

## End(Not run)
```

---

plot.PLNnetworkfit *Extract and plot the network (partial correlation, support or inverse covariance) from a* PLNnetworkfit *object*

Description

Extract and plot the network (partial correlation, support or inverse covariance) from a PLNnetworkfit object

Usage

```
## S3 method for class 'PLNnetworkfit'
plot(
  x,
  type = c("partial_cor", "support"),
  output = c("igraph", "corrplot"),
  edge.color = c("#F8766D", "#00BFC4"),
  remove.isolated = FALSE,
  node.labels = NULL,
  layout = layout_in_circle,
  plot = TRUE,
  ...
)
```

Arguments

x	an R6 object with class PLNnetworkfit
type	character. Value of the weight of the edges in the network, either "partial_cor" (partial correlation) or "support" (binary). Default is "partial_cor".
output	the type of output used: either 'igraph' or 'corrplot'. Default is 'igraph'.
edge.color	Length 2 color vector. Color for positive/negative edges. Default is c("#F8766D","#00BFC4"). Only relevant for igraph output.
remove.isolated	if TRUE, isolated node are remove before plotting. Only relevant for igraph output.
node.labels	vector of character. The labels of the nodes. The default will use the column names ot the response matrix.
layout	an optional igraph layout. Only relevant for igraph output.
plot	logical. Should the final network be displayed or only sent back to the user. Default is TRUE.
...	Not used (S3 compatibility).

Value

Send back an invisible object (igraph or Matrix, depending on the output chosen) and optionally displays a graph (via igraph or corrplot for large ones)

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
fits <- PLNnetwork(Abundance ~ 1, data = trichoptera)
myNet <- getBestModel(fits)
## Not run:
plot(myNet)

## End(Not run)
```

---

plot.PLNPCAfamily *Display the criteria associated with a collection of PLNPCA fits (a PLNPCAfamily)*

Description

Display the criteria associated with a collection of PLNPCA fits (a PLNPCAfamily)

Usage

```
## S3 method for class 'PLNPCAfamily'
plot(x, criteria = c("loglik", "BIC", "ICL"), annotate = TRUE, ...)
```

Arguments

x	an R6 object with class PLNfamily
criteria	vector of characters. The criteria to plot in c("loglik", "BIC", "ICL", "R_squared"). Default is c("loglik", "BIC", "ICL").
annotate	logical: should the value of approximated R squared be added to the plot?
...	additional parameters for S3 compatibility. Not used

Value

Produces a plot representing the evolution of the criteria of the different models considered, highlighting the best model in terms of BIC and ICL (the greater, the better). These criteria have the form 'loglik - 1/2 * penalty' so that they are on the same scale as the model loglikelihood.

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPCAs <- PLNPCA(Abundance ~ 1 + offset(log(Offset)), data = trichoptera, ranks = 1:5)
## Not run:
plot(myPCAs)

## End(Not run)
```

---

plot.PLNPCAfit *PCA visualization (individual and/or variable factor map(s)) for a PLNPCAfit object*

Description

PCA visualization (individual and/or variable factor map(s)) for a PLNPCAfit object

Usage

```
## S3 method for class 'PLNPCAfit'
plot(
  x,
  map = c("both", "individual", "variable"),
  nb_axes = min(3, x$rank),
  axes = seq.int(min(2, x$rank)),
  ind_cols = "ind_colors",
  var_cols = "var_colors",
  plot = TRUE,
  main = NULL,
  ...
)
```

Arguments

x	an R6 object with class PLNPCAfit
map	the type of output for the PCA visualization: either "individual", "variable" or "both". Default is "both".
nb_axes	scalar: the number of axes to be considered when map = "both". The default is min(3,rank).
axes	numeric, the axes to use for the plot when map = "individual" or map = "variable". Default it c(1,min(rank))
ind_cols	a character, factor or numeric to define the color associated with the individuals. By default, all variables receive the default color of the current palette.
var_cols	a character, factor or numeric to define the color associated with the variables. By default, all variables receive the default color of the current palette.
plot	logical. Should the plot be displayed or sent back as ggplot object
main	character. A title for the single plot (individual or variable factor map). If NULL (the default), an hopefully appropriate title will be used.
...	Not used (S3 compatibility).

Value

displays an individual and/or variable factor maps for the corresponding axes, and/or sends back a ggplot or gtable object

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPCAs <- PLNPCA(Abundance ~ 1 + offset(log(Offset)), data = trichoptera, ranks = 1:5)
myPCA <- getBestModel(myPCAs)
## Not run:
plot(myPCA, map = "individual", nb_axes=2, ind_cols = trichoptera$Group)
plot(myPCA, map = "variable", nb_axes=2)
plot(myPCA, map = "both", nb_axes=2, ind_cols = trichoptera$Group)

## End(Not run)
```

---

predict.PLNfit *Predict counts of a new sample*

Description

Predict counts of a new sample

Usage

```
## S3 method for class 'PLNfit'
predict(object, newdata, type = c("link", "response"), ...)
```

Arguments

object	an R6 object with class PLNfit
newdata	A data frame in which to look for variables and offsets with which to predict
type	The type of prediction required. The default is on the scale of the linear predictors (i.e. log average count)
...	additional parameters for S3 compatibility. Not used

Value

A matrix of predicted log-counts (if type = "link") or predicted counts (if type = "response").

---

predict.PLNLDAfit *Predict group of new samples*

Description

Predict group of new samples

Usage

```
## S3 method for class 'PLNLDAfit'
predict(
  object,
  newdata,
  type = c("posterior", "response", "scores"),
  scale = c("log", "prob"),
  prior = NULL,
  control = list(),
  ...
)
```

Arguments

object	an R6 object with class PLNLDAfit
newdata	A data frame in which to look for variables, offsets and counts with which to predict.
type	The type of prediction required. The default are posterior probabilities for each group (in either unnormalized log-scale or natural probabilities, see "scale" for details), "response" is the group with maximal posterior probability and "scores" is the average score along each separation axis in the latent space, with weights equal to the posterior probabilities.
scale	The scale used for the posterior probability. Either log-scale ("log", default) or natural probabilities summing up to 1 ("prob").
prior	User-specified prior group probabilities in the new data. If NULL (default), prior probabilities are computed from the learning set.
control	a list for controlling the optimization. See PLN() for details.
...	additional parameters for S3 compatibility. Not used

Value

A matrix of posterior probabilities for each group (if type = "posterior"), a matrix of (average) scores in the latent space (if type = "scores") or a vector of predicted groups (if type = "response").

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myLDA <- PLNLDA(Abundance ~ 0 + offset(log(Offset)),
                grouping = Group,
                data = trichoptera)
## Not run:
post_probs <- predict(myLDA, newdata = trichoptera, type = "posterior", scale = "prob")
head(round(post_probs, digits = 3))
predicted_group <- predict(myLDA, newdata = trichoptera, type = "response")
table(predicted_group, trichoptera$Group, dnn = c("predicted", "true"))

## End(Not run)
```

`prepare_data` *Prepare data for use in PLN models*

Description

Prepare data in proper format for use in PLN model and its variants. The function (i) merges a count table and a covariate data frame in the most comprehensive way and (ii) computes offsets from the count table using one of several normalization schemes (TSS, CSS, RLE, GMPR, etc). The function fails with informative messages when the heuristics used for sample matching fail.

Usage

```
prepare_data(counts, covariates, offset = "TSS", ...)
```

Arguments

`counts`	Required. An abundance count table, preferably with dimensions names and species as columns.
`covariates`	Required. A covariates data frame, preferably with row names.
`offset`	Optional. Normalization scheme used to compute scaling factors used as offset during PLN inference. Available schemes are "TSS" (Total Sum Scaling, default), "CSS" (Cumulative Sum Scaling, used in metagenomeSeq), "RLE" (Relative Log Expression, used in DESeq2), "GMPR" (Geometric Mean of Pairwise Ratio, introduced in Chen et al., 2018) or "none". Alternatively the user can supply its own vector or matrix of offsets (see note for specification of the user-supplied offsets).
`...`	Additional parameters passed on to `compute_offset()`

Value

A data.frame suited for use in PLN() and its variants with two specials components: an abundance count matrix (in component "Abundance") and an offset vector/matrix (in component "Offset", only if offset is not set to "none")

Note

User supplied offsets should be either vectors/column-matrices or have the same number of column as the original count matrix and either (i) dimension names or (ii) the same dimensions as the count matrix. Samples are trimmed in exactly the same way to remove empty samples.

References

Chen, L., Reeve, J., Zhang, L., Huang, S., Wang, X. and Chen, J. (2018) GMPR: A robust normalization method for zero-inflated count data with application to microbiome sequencing data. PeerJ, 6, e4600 https://doi.org/10.7717/peerj.4600

Paulson, J. N., Colin Stine, O., Bravo, H. C. and Pop, M. (2013) Differential abundance analysis for microbial marker-gene surveys. Nature Methods, 10, 1200-1202 http://dx.doi.org/10.1038/nmeth.2658

Anders, S. and Huber, W. (2010) Differential expression analysis for sequence count data. Genome Biology, 11, R106 https://doi.org/10.1186/gb-2010-11-10-r106

See Also

compute_offset() for details on the different normalization schemes

Examples

```
data(trichoptera)
proper_data <- prepare_data(
 counts     = trichoptera$Abundance,
 covariates = trichoptera$Covariate,
 offset     = "TSS"
)
proper_data$Abundance
proper_data$Offset
```

---

rPLN *PLN RNG*

Description

Random generation for the PLN model with latent mean equal to mu, latent covariance matrix equal to Sigma and average depths (sum of counts in a sample) equal to depths

Usage

```
rPLN(
  n = 10,
  mu = rep(0, ncol(Sigma)),
  Sigma = diag(1, 5, 5),
  depths = rep(10000, n)
)
```

Arguments

n	the sample size
mu	vectors of means of the latent variable
Sigma	covariance matrix of the latent variable
depths	Numeric vector of target depths. The first is recycled if there are not n values

Details

The default value for mu and Sigma assume equal abundances and no correlation between the different species.

Value

a n * p count matrix, with row-sums close to depths

Examples

```
## 10 samples of 5 species with equal abundances, no covariance and target depths of 10,000
rPLN()
## 2 samples of 10 highly correlated species with target depths 1,000 and 100,000
## very different abundances
mu <- rep(c(1, -1), each = 5)
Sigma <- matrix(0.8, 10, 10); diag(Sigma) <- 1
rPLN(n=2, mu = mu, Sigma = Sigma, depths = c(1e3, 1e5))
```

---

sigma.PLNfit *Extract variance-covariance of residuals 'Sigma'*

Description

Extract the variance-covariance matrix of the residuals, usually noted

$$\Sigma$$

in PLN models. This captures the correlation between the species in the latent space.

Usage

```
## S3 method for class 'PLNfit'
sigma(object, ...)
```

Arguments

object	an R6 object with class PLNfit
...	additional parameters for S3 compatibility. Not used

Value

A semi definite positive matrix of size p, assuming there are p species in the model.

See Also

coef.PLNfit(), standard_error.PLNfit() and vcov.PLNfit() for other ways to access

$$\Sigma$$

.

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPLN <- PLN(Abundance ~ 1 + offset(log(Offset)), data = trichoptera)
sigma(myPLN) ## Sigma
```

---

stability_selection *Compute the stability path by stability selection*

Description

This function computes the StARS stability criteria over a path of penalties. If a path has already been computed, the functions stops with a message unless force = TRUE has been specified.

Usage

```
stability_selection(
  Robject,
  subsamples = NULL,
  control = list(),
  mc.cores = 1,
  force = FALSE
)
```

Arguments

Robject	an object with class PLNnetworkfamily, i.e. an output from PLNnetwork()
subsamples	a list of vectors describing the subsamples. The number of vectors (or list length) determines th number of subsamples used in the stability selection. Automatically set to 20 subsamples with size 10*sqrt(n) if n >= 144 and 0.8*n otherwise following Liu et al. (2010) recommendations.
control	a list controlling the main optimization process in each call to PLNnetwork. See PLNnetwork() for details.
mc.cores	the number of cores to used. Default is 1.
force	force computation of the stability path, even if a previous one has been detected.

Value

the list of subsamples. The estimated probabilities of selection of the edges are stored in the fields stability_path of the initial Robject with class PLNnetworkfamily

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
fits <- PLNnetwork(Abundance ~ 1, data = trichoptera)
## Not run:
n <- nrow(trichoptera)
subs <- replicate(10, sample.int(n, size = n/2), simplify = FALSE)
stability_selection(nets, subsamples = subs)

## End(Not run)
```

---

standard_error *Component-wise standard errors of Theta*

Description

Extracts univariate standard errors for the estimated coefficient of Theta. Standard errors are computed from the (approximate) Fisher information matrix. See fisher.PLNfit() for more details on the approximations.

Usage

```
standard_error(object, type)

## S3 method for class 'PLNfit'
standard_error(object, type = c("wald", "louis"))
```

Arguments

`object`	an R6 object with class PLNfit
`type`	Either `Wald` (default) or `Louis`. Approximation scheme used to compute the Fisher information matrix

Value

A p * d positive matrix (same size as Θ) with standard errors for the coefficients of Θ

Methods (by class)

- `PLNfit`: Component-wise standard errors of Theta in `PLNfit`

See Also

`vcov.PLNfit()` for the complete Fisher information matrix

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPLN <- PLN(Abundance ~ 1 + offset(log(Offset)), data = trichoptera)
standard_error(myPLN, "wald")
```

`trichoptera` *Trichoptera data set*

Description

Data gathered between 1959 and 1960 during 49 insect trapping nights. For each trapping night, the abundance of 17 Trichoptera species is recorded as well as 6 meteorological variables which may influence the abundance of each species. Finally, the observations (that is to say, the trapping nights), have been classified into 12 groups corresponding to contiguous nights between summer 1959 and summer 1960.

Usage

```
trichoptera
```

Format

A list with 2 two data frames:

`Abundance` a 49 x 17 matrix of abundancies/counts (49 trapping nights and 17 trichoptera species)

Covariate a 49 x 7 data frame of covariates:

Temperature Evening Temperature in Celsius

Wind Wind in m/s

Pressure Pressure in mm Hg

Humidity relative to evening humidity in percent

Cloudiness proportion of sky coverage at 9pm

Precipitation Nighttime precipitation in mm

Group a factor of 12 levels for the definition of the consecutive night groups

In order to prepare the data for using formula in multivariate analysis (multiple outputs and inputs), use `prepare_data()`. We only kept a subset of the original meteorological covariates for illustration purposes.

Source

Data from P. Usseglio-Polatera.

References

Usseglio-Polatera, P. and Auda, Y. (1987) Influence des facteurs météorologiques sur les résultats de piégeage lumineux. Annales de Limnologie, 23, 65–79. (code des espèces p. 76) See a data description at http://pbil.univ-lyon1.fr/R/pdf/pps034.pdf (in French)

See Also

`prepare_data()`

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
```

---

vcov.PLNfit *Calculate Variance-Covariance Matrix for a fitted `PLN()` model object*

Description

Returns the variance-covariance matrix of the main parameters of a fitted `PLN()` model object. The main parameters of the model correspond to

$$\Theta$$

, as returned by `coef.PLNfit()`. The function can also be used to return the variance-covariance matrix of the residuals. The latter matrix can also be accessed via `sigma.PLNfit()`

Usage

```
## S3 method for class 'PLNfit'
vcov(object, type = c("main", "covariance"), ...)
```

Arguments

object	an R6 object with class PLNfit
type	type of parameter that should be extracted. Either "main" (default) for Θ or "covariance" for Σ
...	additional parameters for S3 compatibility. Not used

Value

A matrix of variance/covariance extracted from the PLNfit model. If type="main" and Θ is a matrix of size d * p, the result is a block-diagonal matrix with p (number of species) blocks of size d (number of covariates). if type="main", it is a symmetric matrix of size p. .

See Also

sigma.PLNfit(), coef.PLNfit(), standard_error.PLNfit()

Examples

```
data(trichoptera)
trichoptera <- prepare_data(trichoptera$Abundance, trichoptera$Covariate)
myPLN <- PLN(Abundance ~ 1 + offset(log(Offset)), data = trichoptera)
vcov(myPLN) ## variance-covariance of Theta
vcov(myPLN, type = "covariance") ## Sigma
```

Index