Package 'GGMinference'

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Type Package

Title Inference for Undirected Gaussian Graphical Models

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Description Confidence intervals for edges in high-dimensional undirected Gaussian graphical models and p-values for testing their significance. The confidence intervals can be based either on the graphical lasso or the neighbourhood lasso (in the high-dimensional case) and on the precision matrix (in the low-dimensional case).

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Imports glmnet, MASS, stats, RPtests, glasso,

Encoding UTF-8

LazyData true

RoxygenNote 6.1.1

R topics documented:

`glasso.pvals` *P-values and confidence intervals based on the graphical lasso.*

Description

P-values and confidence intervals for edge weights in high-dimensional undirected Gaussian graphical models. The method is based on the graphical lasso as the initial estimator. For details on the methodology, see Janková, J. and van de Geer, S. (2015) *Confidence intervals for high-dimensional inverse covariance estimation.*

Usage

```
glasso.pvals(X, standardize = FALSE, alpha = 0.05,
  rho0 = sqrt(log(ncol(X))/nrow(X)), theta0 = matrix(0, ncol(X),
  ncol(X)), pmethod = "BH", visual = FALSE)
```

Arguments

X	Input matrix with n rows, each an observation vector.
standardize	Should design matrix be standardized to unit column standard deviation.
alpha	Significance level for testing and confidence intervals.
rho0	Regularization parameter for glasso.
theta0	(Optional) A pxp matrix for custom testing of hypothesis theta_ij = theta0_ij.
pmethod	Method to use for multiple testing correction (one of 'holm', 'hochberg', 'hommel', 'bonferroni', 'BH', BY','fdr', 'none'). The default is "BH".
visual	Logical indicating whether a heatmap of adjusted p-values should be plotted. Default is False.

Value

Returns a list containing p-values, adjusted p-values, confidence intervals and significant variables as specified below.

pvals	pxp matrix containing individual p-values for each parameter.
pvals.adjusted	pxp matrix containing p-values for each parameter, corrected with a multiple-testing adjustment specified by pmethod.
conf.ints	A list with two pxp matrices: the matrices hold upper and lower bounds of individual confidence intervals respectively (without multiple testing adjustment).
selected	A matrix with 2 columns where rows are pairs of coordinates of edges that are selected as significant at level alpha (with multiple testing adjustment as specified by pmethod).

References

Janková, J. and van de Geer, S. (2015,2017,2018) *Inference in high-dimensional undirected graphical models* https://arxiv.org/abs/1801.08512

Examples

```
# Inference for edge weights using data generated from a Gaussian graphical model
library(MASS)
set.seed(1)

p <- 100
n <- 150
rho <-  0.3
Theta <- diag(p) + cbind(rho*diag(p)[,-1], rep(0,p)) + t(cbind(rho*diag(p)[,-1], rep(0,p)))

X <- mvrnorm(n, rep(0,p), Sigma = solve(Theta))

glasso.inference <- glasso.pvals(X, standardize = FALSE, alpha = 0.05,
                    rho0 = sqrt(log(p)/n), pmethod = "BH", visual = FALSE)
```

```
glasso.inference$p.values.adjusted
```

`nodewiselasso.pvals` *P-values and confidence intervals based on the nodewise (neighbourhood) lasso.*

Description

P-values and confidence intervals for edge weights in high-dimensional undirected Gaussian graphical models. The method is based on the nodewise (neighbourhood) lasso as the initial estimator. For details on the methodology, see Janková, J. and van de Geer, S. (2017) *Honest confidence regions and optimality in high-dimensional precision matrix estimation*.

Usage

```
nodewiselasso.pvals(X, standardize = FALSE, alpha = 0.05,
  theta0 = matrix(0, ncol(X), ncol(X)), pmethod = "BH",
  visual = FALSE)
```

Arguments

`X`	Input matrix with `n` rows and `p` columns, each row an observation vector.
`standardize`	Should design matrix be standardized to unit column standard deviation.
`alpha`	Significance level for testing and confidence intervals.
`theta0`	(Optional) A `pxp` matrix for custom testing of hypothesis theta_ij = theta0_ij.
`pmethod`	Method to use for multiple testing correction ("holm", "hochberg", "hommel", 'bonferroni', 'BH', "BY","fdr" or "none"). The default is "BH".
`visual`	Logical indicating whether a heatmap of adjusted p-values should be plotted. Default is False.

Value

Returns a list containing p-values, adjusted p-values, confidence intervals and significant variables as specified below.

`pvals`	`pxp` matrix containing individual p-values for each parameter.
`pvals.adjusted`	`pxp` matrix containing p-values for each parameter, corrected with a multiple-testing adjustment specified by `pmethod`.
`conf.ints`	A list with two `pxp` matrices: the matrices hold upper and lower bounds of individual confidence intervals respectively (without multiple testing adjustment).
`selected`	A matrix with 2 columns where rows are pairs of coordinates of edges that are selected as significant at level `alpha` (with multiple testing adjustment as specified by `pmethod`).

References

Janková, J. and van de Geer, S. (2018) *Inference in high-dimensional undirected graphical models* https://arxiv.org/abs/1801.08512

Examples

```
# Inference for edge weights using data generated from a Gaussian graphical model

library(MASS)
set.seed(1)

p <- 100
n <- 150
rho <-  0.3
Theta <- diag(p) + cbind(rho*diag(p)[,-1], rep(0,p)) + t(cbind(rho*diag(p)[,-1], rep(0,p)))

X <- mvrnorm(n, rep(0,p), Sigma = solve(Theta))

nlasso.inference <- nodewiselasso.pvals(X, standardize = FALSE, alpha = 0.05, visual = FALSE)
nlasso.inference$p.values.adjusted
```

`precmat.pvals` *P-values and confidence intervals based on the precision matrix (inverse covariance matrix)*

Description

P-values and confidence intervals for edge weights in high-dimensional undirected Gaussian graphical models. The method is based on the inverse sample covariance estimator and works only when `ncol(X) < nrow(X)` (i.e. low-dimensional case).

Usage

```
precmat.pvals(X, standardize = FALSE, alpha = 0.05,
  theta0 = matrix(0, ncol(X), ncol(X)), pmethod = "BH",
  visual = FALSE)
```

Arguments

`X`	Input matrix with n rows, each an observation vector.
`standardize`	Should design matrix be standardized to unit column standard deviation.
`alpha`	Level of the confidence intervals.
`theta0`	(Optional) A pxp matrix for custom testing of hypothesis theta_ij = theta0_ij.
`pmethod`	Method to use for multiple testing correction (one of 'holm', 'hochberg', 'hommel', 'bonferroni', 'BH', BY','fdr', 'none'). The default is "BH".
`visual`	Logical indicating whether a heatmap of adjusted p-values should be plotted. Default is False.

Value

Returns a list containing p-values, adjusted p-values, confidence intervals and significant variables as specified below.

`pvals`	pxp matrix containing individual p-values for each parameter.

pvals.adjusted	pxp matrix containing p-values for each parameter, corrected with a multiple-testing adjustment specified by pmethod.
conf.ints	A list with two pxp matrices: the matrices hold upper and lower bounds of individual confidence intervals respectively (without multiple testing adjustment).
selected	A matrix with 2 columns where rows are pairs of coordinates of edges that are selected as significant at level alpha (with multiple testing adjustment as specified by pmethod).

References

Janková, J. and van de Geer, S. (2015,2017,2018) *Inference in high-dimensional undirected graphical models* https://arxiv.org/abs/1801.08512

Examples

```
# Inference for edge weights using data generated from a Gaussian graphical model

library(MASS)
set.seed(1)

p <- 100
n <- 150
rho <-  0.3
Theta <- diag(p) + cbind(rho*diag(p)[,-1], rep(0,p)) + t(cbind(rho*diag(p)[,-1], rep(0,p)))

X <- mvrnorm(n, rep(0,p), Sigma = solve(Theta))

precmat.inference <- precmat.pvals(X, standardize = FALSE, alpha = 0.05,
                                   pmethod = "BH", visual = FALSE)

precmat.inference$p.values.adjusted
```

Index