

Package ‘glasso’

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Title Graphical lasso- estimation of Gaussian graphical models

Version 1.4

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Description Graphical lasso

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glasso	<i>Graphical lasso</i>
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Description

Estimates a sparse inverse covariance matrix using a lasso (L1) penalty

Usage

```
glasso(s, rho, zero=NULL, thr=1.0e-4, maxit=1e4, approx=FALSE, penalize.diagonal=
```

Arguments

<code>s</code>	Covariance matrix: p by p matrix (symmetric)
<code>rho</code>	(Non-negative) regularization parameter for lasso. <code>rho=0</code> means no regularization. Can be a scalar (usual) or a symmetric p by p matrix, or a vector of length p. In the latter case, the penalty matrix has jkth element $\sqrt{\text{rho}[j]*\text{rho}[k]}$.
<code>zero</code>	(Optional) indices of entries of inverse covariance to be constrained to be zero. The input should be a matrix with two columns, each row indicating the indices of elements to be constrained to be zero. The solution must be symmetric, so you need only specify one of (j,k) and (k,j). An entry in the zero matrix overrides any entry in the rho matrix for a given element.
<code>thr</code>	Threshold for convergence. Default value is 1e-4. Iterations stop when average absolute parameter change is less than <code>thr * ave(abs(offdiag(s)))</code>
<code>maxit</code>	Maximum number of iterations of outer loop. Default 10,000
<code>approx</code>	Approximation flag: if true, computes Meinhausen-Buhlmann(2006) approximation
<code>penalize.diagonal</code>	Should diagonal of inverse covariance be penalized? Default TRUE.
<code>start</code>	Type of start. Cold start is default. Using Warm start, can provide starting values for w and wi
<code>w.init</code>	Optional starting values for estimated covariance matrix (p by p). Only needed when <code>start="warm"</code> is specified
<code>wi.init</code>	Optional starting values for estimated inverse covariance matrix (p by p) Only needed when <code>start="warm"</code> is specified
<code>trace</code>	Flag for printing out information as iterations proceed. Default FALSE

Details

Estimates a sparse inverse covariance matrix using a lasso (L1) penalty, using the approach of Friedman, Hastie and Tibshirani (2007). The Meinhausen-Buhlmann (2006) approximation is also implemented. The algorithm can also be used to estimate a graph with missing edges, by specifying which edges to omit in the zero argument, and setting `rho=0`. Or both fixed zeroes for some elements and regularization on the other elements can be specified.

Value

A list with components

<code>w</code>	Estimated covariance matrix
<code>wi</code>	Estimated inverse covariance matrix
<code>loglik</code>	Value of maximized log-likelihood+penalty
<code>errflag</code>	Memory allocation error flag: 0 means no error; !=0 means memory allocation error - no output returned
<code>approx</code>	Value of input argument <code>approx</code>
<code>del</code>	Change in parameter value at convergence
<code>niter</code>	Number of iterations of outer loop used by algorithm

References

Jerome Friedman, Trevor Hastie and Robert Tibshirani (2007). Sparse inverse covariance estimation with the lasso. *Biostatistics* 2007. <http://www-stat.stanford.edu/~tibs/ftp/graph.pdf>

Meinshausen, N. and Buhlmann, P.(2006) High dimensional graphs and variable selection with the lasso. *Annals of Statistics*,34, p1436-1462.

Examples

```
set.seed(100)

x<-matrix(rnorm(50*20),ncol=20)
s<- var(x)
a<-glasso(s, rho=.01)
aa<-glasso(s,rho=.02, w.init=a$w, wi.init=a$wi)

# example with structural zeros and no regularization,
# from Whittaker's Graphical models book page xxx.

s=c(10,1,5,4,10,2,6,10,3,10)
S=matrix(0,nrow=4,ncol=4)
S[row(S)>=col(S)]=s
S=(S+t(S))
diag(S)<-10
zero<-matrix(c(1,3,2,4),ncol=2,byrow=TRUE)
a<-glasso(S,0,zero=zero)
```

glassopath

Compute the Graphical lasso along a path

Description

Estimates a sparse inverse covariance matrix using a lasso (L1) penalty, along a path of values for the regularization parameter

Usage

```
glassopath(s, rholist=NULL, thr=1.0e-4, maxit=1e4, approx=FALSE, penalize.diagonal)
```

Arguments

`s` Covariance matrix: p by p matrix (symmetric)

`rholist` Vector of non-negative regularization parameters for the lasso. Should be increasing from smallest to largest; actual path is computed from largest to smallest value of ρ . If `NULL`, 10 values in a (hopefully reasonable) range are used. Note that the same parameter `rholist[j]` is used for all entries of the inverse covariance matrix; different penalties for different entries are not allowed.

<code>thr</code>	Threshold for convergence. Default value is 1e-4. Iterations stop when average absolute parameter change is less than <code>thr * ave(abs(offdiag(s)))</code>
<code>maxit</code>	Maximum number of iterations of outer loop. Default 10,000
<code>approx</code>	Approximation flag: if true, computes Meinhausen-Buhlmann(2006) approximation
<code>penalize.diagonal</code>	Should diagonal of inverse covariance be penalized? Default TRUE.
<code>w.init</code>	Optional starting values for estimated covariance matrix (p by p). Only needed when <code>start="warm"</code> is specified
<code>wi.init</code>	Optional starting values for estimated inverse covariance matrix (p by p) Only needed when <code>start="warm"</code> is specified
<code>trace</code>	Flag for printing out information as iterations proceed. Default FALSE

Details

Estimates a sparse inverse covariance matrix using a lasso (L1) penalty, along a path of regularization parameters, using the approach of Friedman, Hastie and Tibshirani (2007). The Meinhausen-Buhlmann (2006) approximation is also implemented. The algorithm can also be used to estimate a graph with missing edges, by specifying which edges to omit in the zero argument, and setting `rho=0`. Or both fixed zeroes for some elements and regularization on the other elements can be specified.

Value

A list with components

<code>w</code>	Estimated covariance matrices, an array of dimension <code>(nrow(s),ncol(n), length(rholist))</code>
<code>wi</code>	Estimated inverse covariance matrix, an array of dimension <code>(nrow(s),ncol(n), length(rholist))</code>
<code>approx</code>	Value of input argument <code>approx</code>
<code>rholist</code>	Values of regularization parameter used
<code>errflag</code>	values of error flag (0 means no memory allocation error)

References

Jerome Friedman, Trevor Hastie and Robert Tibshirani (2007). Sparse inverse covariance estimation with the lasso. *Biostatistics* 2007. <http://www-stat.stanford.edu/~tibs/ftp/graph.pdf>

Meinshausen, N. and Buhlmann, P.(2006) High dimensional graphs and variable selection with the lasso. *Annals of Statistics*,34, p1436-1462.

Examples

```
set.seed(100)

x<-matrix(rnorm(50*20),ncol=20)
s<- var(x)
a<-glassopath(s)
```

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