# Package 'lglasso'

January 15, 2022

**Type** Package

**Title** Longitudinal Graphical Lasso

**Version** 0.1.0

**Description** For high-dimensional correlated observations, this package carries out the L_1 penalized maximum likelihood
estimation of the precision matrix (network) and the correlation parameters. The correlated data can be
longitudinal data (may be irregularly spaced) with dampening correlation or clustered data with uniform correlation.
For the details of the algorithms, please see the paper Jie Zhou et al. Identifying Microbial Interaction Networks Based on Irregularly Spaced
Longitudinal 16S rRNA sequence data <doi:10.1101/2021.11.26.470159>.

**License** GPL-3

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 7.1.2

**URL** https://github.com/jiezhou-2/lglasso

**Suggests** knitr, rmarkdown

**Imports** stats, glasso

**Depends** R (>= 2.10)

**NeedsCompilation** no

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**Repository** CRAN

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# R topics documented:



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`heterlongraph` *Estimates of correlation parameters and precision matrix*

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## Description

Estimates of correlation parameters and precision matrix

## Usage

```
heterlongraph(data, rho, type, tole, lower, upper)
```

## Arguments

| | |
|---|---|
| `data` | Data matrix in which the first column is subject id, the second column is the time points of observation. Columns 2 to (p+2) is the observations for p variables. |
| `rho` | Tuning parameter used in graphical lasso |
| `type` | Type of correlation function, which can take either "abs" or "sqr". |
| `tole` | Error tolerance for determination of convergence of EM algorithm |
| `lower` | Lower bound for prediction of correlation parameter tau |
| `upper` | Upper bound for prediction of correlation parameter tau |

## Value

S list with three components which are the final estimate of alpha, tau and precision matrix omega

## Author(s)

Jie Zhou

## homolongraph — *Estiamte of precision matrix and autocorrelaton parameter for homogeneous model*

### Description

Estiamte of precision matrix and autocorrelaton parameter for homogeneous model

### Usage

```
homolongraph(data, rho, type, tole, lower, upper)
```

### Arguments

| | |
|---|---|
| data | Data matrix in which the first column is subject id, the second column is the time points of observation. Columns 2 to (p+2) is the observations for p variables. |
| rho | Tuning parameter for graphical lasso |
| type | Type of correlation function, which can take either "abs" or "qua". |
| tole | Error tolerance for determination of convergence of EM algorithm |
| lower | Lower bound for prediction of correlation parameter tau |
| upper | Upper bound for prediction of correlation parameter tau |

### Value

A list for estimates of precision matrix and correlation parameter for given tuning parameter

### Author(s)

Jie Zhou

## iss — *Quasi covariance matrix for subject i*

### Description

Quasi covariance matrix for subject i

### Usage

```
iss(idata, itau, type)
```

### Arguments

| | |
|---|---|
| idata | Data matrix for the subject i in which the first column is subject (cluster) id, the second column stands for the time points () of observation. Columns 2 to (p+2) is the observations for p variables respectively. |
| itau | Correlation parameter |
| type | Type of correlation function, which typically take either 0, 1 or 2. |

### Value

Empirical quasi covariance matrix

### Author(s)

Jie Zhou

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## lglasso *Graphical Lasso for Longitudinal Data*

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### Description

This function implements the L_1 penalized maximum likelihood estimation for precision matrix (network) based on correlated data, e.g., irregularly spaced longitudinal data. It can be regarded as an extension of the package `glasso` (Friedman,Hastie and Tibshirani, 2008) which aims to find the sparse estimate of the network from independent continuous data.

### Usage

```
lglasso(
  data,
  rho,
  heter = TRUE,
  type = 1,
  tole = 0.01,
  lower = 0.01,
  upper = 10
)
```

### Arguments

| | |
|---|---|
| data | Data matrix in which the first column is subject id, the second column is time points of observations for temporal data or site id for spatial data. Columns `3` to `(p+2)` is the observations for `p` variables. |
| rho | Tuning parameter used in `L_1` penalty |

| | |
|---|---|
| heter | Binary variable TRUE or FALSE, indicating heterogeneous model or homogeneous model is fitted. In heterogeneous model, subjects are allowed to have his/her own temporal correlation parameter tau_i; while in homogeneous model, all the subjects are assumed to share the same temporal correlation parameter,i.e., tau_1=tau_2=...tau_m. |
| type | A positive number which specify the correlation function. The general form of correlation function is given by exp(tau\|t_i-t_j\|^type). in which type=0 can be used for spatial correlation while type>0 are used for temporal correlation. For latter, the default value is set to be type=1. |
| tole | Threshold for convergence. Default value is 1e-2. Iterations stop when maximum absolute difference between consecutive estimates of parameter change is less than tole. |
| lower | Lower bound for predicts of correlation parameter tau. Default value is 1e-2. The estimate of tau(alpha) will be searched in the interval [lower,upper], where parameter upper is explained in the following. |
| upper | Upper bound for predicts of correlation parameter tau. |

## Value

If heter=TRUE, then a list with three components is returned which are respectively the estimate of parameter alpha in exponent distribution, correlation parameter tau and precision matrix omega. If heter=FALSE, then a list with two components is returned which are respectively the estimate of correlation parameter tau and precision matrix omega.

## Author(s)

Jie Zhou

## References

Jie Zhou, Jiang Gui, Weston D.Viles, Anne G.Hoen Identifying Microbial Interaction Networks Based on Irregularly Spaced Longitudinal 16S rRNA sequence data. bioRxiv 2021.11.26.470159; doi: https://doi.org/10.1101/2021.11.26.470159

Friedman J, Tibshirani TH and R. Glasso: Graphical Lasso: Estimation of Gaussian Graphical Models.; 2019. Accessed November 28, 2021. https://CRAN.R-project.org/package=glasso

Friedman J, Hastie T, Tibshirani TH, Sparse inverse covariance estimation with the graphical lasso, Biostatistics, Volume 9, Issue 3, July 2008, Pages 432–441, https://doi.org/10.1093/biostatistics/kxm045

## Examples

```
sample_data[1:5,1:5]
dim(sample_data)
## Heterogeneous model with dampening correlation rate using the first three clusters
a=lglasso(data = sample_data[1:11,], rho = 0.7,heter=TRUE, type=1)
### Estimates of correlation parameters
a$tau
### Sub-network for the first five variables
a$omega[1:5,1:5]
```

```
### Total number of the edges in the estimated network
(length(which(a$omega!=0))-ncol(a$omega))/2
## Homogeneous model with dampening correlation rate using the first three clusters
b=lglasso(data = sample_data[1:11,], rho = 0.7,heter=FALSE,type=1)
### Estimates of correlation parameters
b$tau
### Sub-network for the first five  variables
b$omega[1:5,1:5]
### Total number of the edges in the estimated network
(length(which(b$omega!=0))-ncol(b$omega))/2
## Heterogeneous model with uniform correlation rate using the first three clusters
c=lglasso(data = sample_data[1:11,], rho = 0.7,heter=TRUE,type=0)
### Estimates of correlation parameters
c$tau
### Sub-network for the first five  variables
c$omega[1:5,1:5]
### Total number of the edges in the estimated network
(length(which(c$omega!=0))-ncol(c$omega))/2
## Homogeneous model with uniform correlation rate using the first three clusters
d=lglasso(data = sample_data[1:11,], rho = 0.7,heter=FALSE,type=0)
### Estimates of correlation parameters
d$tau
### Sub-network for the first five  variables
d$omega[1:5,1:5]
### Total number of the edges in the estimated network
(length(which(d$omega!=0))-ncol(d$omega))/2
```

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`lli_homo` *full log likelihood used in EBIC computation*

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## Description

full log likelihood used in EBIC computation

## Usage

```
lli_homo(idata, omega, tau, type)
```

## Arguments

| | |
|---|---|
| `idata` | Data matrix for the subject i in which the first column is id for subject, the second column is the time points of observation. Columns 2 to (p+2) is the observations for p variables. |
| `omega` | Precision matrix |
| `tau` | Correlation parameter |
| `type` | Type of correlation function, which can take either "abs" or "qua". |

## Value

Value of likelihood function for subject i at given omega and tau

## Author(s)

Jie Zhou

---

`ll_homo` *Value of likelihood function at given parameter*

---

## Description

Value of likelihood function at given parameter

## Usage

```
ll_homo(data, omega, tau, type)
```

## Arguments

| | |
|---|---|
| `data` | Data matrix in which the first column is subject id, the second column is the time points of observation. Columns 2 to (p+2) is the observations for p variables. |
| `omega` | Precision matrix |
| `tau` | Correlation parameter |
| `type` | Type of correlation function, which can take either "abs" or "qua". |

## Value

Value of likelihood function at given omega and tau

## Author(s)

Jie Zhou

`logdensity` *Complete likelihood function used in EM algorithm of heterogeneous marginal graphical lasso model*

## Description

Complete likelihood function used in EM algorithm of heterogeneous marginal graphical lasso model

## Usage

```
logdensity(idata, omega, tau, alpha, type)
```

## Arguments

| | |
|---|---|
| `idata` | Data matrix for the subject i in which the first column is id for subject, the second column is the time points of observation. Columns 2 to (p+2) is the observations for p variables. |
| `omega` | Precision matrix |
| `tau` | Correlation parameter |
| `alpha` | Parameter in exponential distribution |
| `type` | Type of correlation function, which can take either "abs" or "qua". |

## Value

Value of complete likelihood function at given value of omega, tau and alpha

## Author(s)

Jie Zhou

`mle` *Maximum Likelihood Estimate of Precision Matrix and Correlation Parameters for Given Network*

## Description

Maximum Likelihood Estimate of Precision Matrix and Correlation Parameters for Given Network

## Usage

```
mle(
  data,
  network,
  heter = TRUE,
  type = 1,
  tole = 0.01,
  lower = 0.01,
  upper = 10
)
```

## Arguments

| | |
|---|---|
| data | Data matrix in which the first column is subject id, the second column is time points of observations for temporal data or site id for spatial data. Columns 3 to (p+2) is the observations for p variables. |
| network | The network selected by function lglasso |
| heter | Binary variable TRUE or FALSE, indicating heterogeneous model or homogeneous model is fitted. In heterogeneous model, subjects are allowed to have his/her own temporal correlation parameter tau_i; while in homogeneous model, all the subjects are assumed to share the same temporal correlation parameter,i.e., tau_1=tau_2=...tau_m. |
| type | A positive number which specify the correlation function. The general form of correlation function is given by exp(tau\|t_i-t_j\|^type). in which type=0 can be used for spatial correlation while type>0 are used for temporal correlation. For latter, the default value is set to be type=1. |
| tole | Threshold for convergence. Default value is 1e-2. Iterations stop when maximum absolute difference between consecutive estimates of parameter change is less than tole. |
| lower | Lower bound for predicts of correlation parameter tau. Default value is 1e-2. The estimate of tau(alpha) will be searched in the interval [lower,upper], where parameter upper is explained in the following. |
| upper | Upper bound for predicts of correlation parameter tau. |

## Value

A list which include the maximum likelihood estimate of precision matrix, correlation parameter tau. If heter=TRUE, the output also include the estimate of alpha where tau~exp(alpha)

## Author(s)

Jie Zhou

## mle_alpha *Maximum likelihood estimate of correlation parameter for given structure of precision matrix*

### Description

Maximum likelihood estimate of correlation parameter for given structure of precision matrix

### Usage

```
mle_alpha(data, alpha0, omega, type, tole, lower, upper)
```

### Arguments

| | |
|---|---|
| data | Data matrix in which the first column is subject id, the second column is the time points of observation. Columns 2 to (p+2) is the observations for p variables. |
| alpha0 | Initial value for the parameter in exponential distribution |
| omega | Fixed value for precision matrix |
| type | Type of correlation function, which can take either "abs" or "qua". |
| tole | Error tolerance for determination of convergence of EM algorithm |
| lower | Lower bound for prediction of correlation parameter tau |
| upper | Upper bound for prediction of correlation parameter tau |

### Author(s)

Jie Zhou

## mle_net *Title*

### Description

Title

### Usage

```
mle_net(data, priori)
```

### Arguments

| | |
|---|---|
| data | A Longitudinal data set |
| priori | Given structure of precision matrix |

## Value

The maximum likelihood estimation

## Author(s)

Jie Zhou

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`mle_tau` *Estiamte of precision matrix and autocorrelaton parameter for homogeneous model*

---

## Description

Estiamte of precision matrix and autocorrelaton parameter for homogeneous model

## Usage

```
mle_tau(data, omega, type, lower, upper)
```

## Arguments

| | |
|---|---|
| `data` | Data matrix in which the first column is subject id, the second column is the time points of observation. Columns 2 to (p+2) is the observations for p variables. |
| `omega` | The maximum likelihood estiamte of precision matrix |
| `type` | Type of correlation function, which can take either "abs" or "qua". |
| `lower` | Lower bound for prediction of correlation parameter tau |
| `upper` | Upper bound for prediction of correlation parameter tau |

## Value

A list for estimates of precision matrix and correlation parameter for given tuning parameter

## Author(s)

Jie Zhou

## phifunction *Construct the temporal component fo correlation function*

### Description

Construct the temporal component fo correlation function

### Usage

```
phifunction(t, tau, type = 1)
```

### Arguments

| | |
|---|---|
| t | Time points of observations |
| tau | correlation parameter |
| type | The type of correlation function, which typically take either 0,1 or 2. |

### Value

A square matrix with dimension equal to the length of vector t

### Author(s)

Jie Zhou

## sample_data *Sample Data*

### Description

The sample data are subset of a larger longitudinal data set from an ongoing large-scale prospective project. There are 13 cluster are involved in the sample data.

### Usage

```
sample_data
```

### Format

A 100-by-22 matrix

**Column 1** Cluster id;

**Column 2** Time points of observations;

**Columns 3-22** Observations for 20 microbes.

# Index