# Package ‘SparseTSCGM’

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**Author** Fentaw Abegaz [aut, cre], Ernst Wit [aut]  
**Maintainer** Fentaw Abegaz <f.abegaz.yazew@rug.nl>  
**Description** Computes sparse vector autoregressive coefficients and precision matrices for time series chain graphical models. Fentaw Abegaz and Ernst Wit (2013)  
**License** GPL (>= 3)  
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SparseTSCGM-package  
 Sparse Time Series Chain Graphical Models.

Description

Computes sparse autoregressive coefficient and precision matrices for time series chain graphical models (TSCGM). These models provide an efficient way of simultaneously dealing with Gaussian graphical models (undirected graphs for instantaneous interactions) and Bayesian networks (directed graphs for dynamic interactions) for reconstructing instantaneous and dynamic networks from repeated multivariate time series data.

Details

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Author(s)

Fentaw Abegaz and Ernst Wit
Maintainer: Fentaw Abegaz <f.abegaz.yazew@rug.nl>

References


Examples

```r
seed = 321
datas <- sim.data(model="ar1", time=10, n.obs=10, n.var=5, seed=seed, prob0=0.35, network="random")
data.fit <- datas$data1
prec_true <- datas$theta
autoR_true <- datas$gamma
```
res.tscgm <- sparse.tscgm(data=data.fit, lam1=NULL, lam2=NULL, nlambda=NULL, 
model="ar1", penalty="scad", optimality="bic_mod", 
control=list(maxit.out = 10, maxit.in = 100))

#Estimated sparse precision and autoregression matrices
prec <- res.tscgm$theta
autoR <- res.tscgm$gamma

#Graphical visualization
oldpar <- par(mfrow=c(2,2))
plot.tscgm(datas, mat="precision",main="True precision matrix")
plot.tscgm(res.tscgm, mat="precision",main="Estimated precision matrix")
plot.tscgm(datas, mat="autoregression",main="True autoregression coef. matrix")
plot.tscgm(res.tscgm, mat="autoregression", 
main="Estimated autoregression coef. matrix")
par(oldpar)

mammary  Microarray gene expression time course data for mammary gland development in mice

Description
The data contains 30 genes identified using cluster analysis from 12488 probe sets representing approximately 8600 genes. The data are measured over 54 arrays of 3 replicates each on 18 time points of the developmental stages of mammary gland in mice. See Stein et al. (2004) for more details.

Usage
data(mammary)

Format
Data is in longitudinal format with 30 columns, 54 rows and a number of extra attributes (see R package longitudinal).

Source
This data is described in Stein et al. (2004) and can be freely obtained from the R package smida.

References
Examples

```r
# load "longitudinal" library
library(longitudinal)

# load data sets
data(mammary)
```

plot.tscgm

Plot sparse.tscgm objects from fitting chain graphical models with vector autoregressive process of order 2.

Description

plot.tscgm is a generic plot function that is adapted for objects of class sparse.tscgm.

Usage

```r
## S3 method for class 'tscgm'
plot(x, mat=c("precision","autoregression"), ...)
```

Arguments

- `x`: an object of class sparse.tscgm.
- `mat`: Name of matrix to be plotted, i.e., either the precision matrix or vector autoregression matrix.
- `...`: Arguments to be passed to graphical parameters (see `par`).

Value

Undirected or directed networks.

Author(s)

Fentaw Abegaz and Ernst Wit

See Also

network

Examples

```r
seed = 321
datas <- sim.data(model="ar1", time=10, n.obs=10, n.var=5, seed=seed, prob0=0.35,
        network="random")
data.fit <- datas$data1

res.tscgm <- sparse.tscgm(data=data.fit, lam1=NULL, lam2=NULL, nlambda=NULL,
```
model="ar1", penalty="scad", optimality="bic_mod", control=list(maxit.out = 10, maxit.in = 100))

#Network visualization
oldpar <- par(mfrow=c(2,1))
plot.tscgm(res.tscgm, mat="precision", main="Undirected network", pad = 0.01,
label.pad = 0.3, label.col = 6, vertex.col = 5, vertex.cex = 1.5,
edge.col = 4, mode = "fruchtermanreingold", interactive=FALSE)

plot.tscgm(res.tscgm, mat="autoregression", main="Directed network", pad = 0.01,
label.pad = 0.3, label.col = 6, vertex.col = 5, vertex.cex = 1.5,
edge.col = 4, mode = "fruchtermanreingold", interactive=FALSE)
par(oldpar)

plot.tscgm.ar2  

Plot sparse.tscgm objects from fitting chain graphical models with vector autoregressive process of order 2.

Description

plot.tscgm.ar2 is a generic plot function that is adapted for objects of class sparse.tscgm.

Usage

## S3 method for class 'tscgm.ar2'
plot(x, mat=c("precision", "autoregression1", "autoregression2"),...)

Arguments

x an object of class sparse.tscgm.

mat Name of matrix to be plotted, i.e., either the precision matrix or vector autoregression matrices of lag 1 or 2.

... Arguments to be passed to graphical parameters (see par).

Value

Undirected or directed networks.

Author(s)

Fentaw Abegaz and Ernst Wit

See Also

network
Examples

```r
## Data generation from time series chain graphical model with vector
## autoregressive model of order 2
seed = 321
datas <- sim.data(model="ar2", time=10, n.obs=20, n.var=5, seed=seed, prob0=0.35,
    network="random")
data.fit <- datas$data1

## Model fitting with vector autoregressive order 2
res.tscgm <- sparse.tscgm(data=data.fit, lam1=NULL, lam2=NULL, nlambda=NULL,
    model="ar2", penalty="scad", optimality="bic_mod", control=list(maxit.out = 10, maxit.in = 100))

#Network visualization
oldpar<-par(mfrow=c(3,2))
plot.tscgm.ar2(datas, mat="precision",main="True precision matrix")
plot.tscgm.ar2(res.tscgm, mat="precision",main="Estimated precision matrix")

plot.tscgm.ar2(datas, mat="autoregression1",
    main="True autoregression coef. matrix of lag 1")
plot.tscgm.ar2(res.tscgm, mat="autoregression1",
    main="Estimated autoregression coef. matrix of lag 1")

plot.tscgm.ar2(datas, mat="autoregression2",
    main="True autoregression coef. matrix of lag 2")
plot.tscgm.ar2(res.tscgm, mat="autoregression2",
    main="Estimated autoregression coef. matrix of lag 2")
par(oldpar)
```

print.tscgm

Print summary - S3 Method for Class ’sparse.tscgm’.

Description

print is a generic function that prints output summaries of fitted models in the SparseTSCGM package.

Usage

```r
## S3 method for class ’tscgm’
print(x, ...)
```

Arguments

- `x`: an object of class `sparse.tscgm`
- `...`: other arguments passed to `print`.

Details

The `print.tscgm` function summarizes and prints results of the fitted model.
Value

Prints summary of results:

Author(s)

Fentaw Abegaz and Ernst Wit

See Also

sparse.tscgm

sim.data

Multivariate time series simulation with chain graphical models

Description

Generates sparse vector autoregressive coefficients matrices and precision matrix from various network structures and using these matrices generates repeated multivariate time series dataset.

Usage

```r
sim.data(model=c("ar1","ar2"),time=time,n.obs=n.obs, n.var=n.var,seed=NULL, prob0=NULL, network=c("random","scale-free","hub","user_defined"), prec=NULL,gamma1=NULL,gamma2=NULL)
```

Arguments

- `model` Specifies the order of vector autoregressive models. Vector autoregressive model of order 1 is applied if `model = "ar1"` and Vector autoregressive model of order 2 is applied if method = "ar2".
- `time` Number of time points.
- `n.obs` Number of observations or replicates.
- `n.var` Number of variables.
- `seed` Random number seed.
- `prob0` Initial sparsity level.
- `network` Specifies the type of network structure. This could be random, scale-free, hub or user defined structures. Details on simulations from the various network structures can be found in the R package flare.
- `prec` Precision matrix.
- `gamma1` Autoregressive coefficients matrix at time lag 1.
- `gamma2` Autoregressive coefficients matrix at time lag 2.
Value

A list containing:

- theta: Sparse precision matrix.
- gamma: Sparse autoregressive coefficients matrix.
- sigma: Covariance matrix.
- data1: Repeated multivariate time series data in longitudinal format.

Author(s)

Fentaw Abegaz and Ernst Wit

Examples

```r
seed = 321
data1 <- sim.data(model="ar1", time=4, n.obs=3, n.var=5, seed=seed, prob0=0.35,
                   network="random")
data.ts <- data1$data1
prec_true <- data1$theta
gamma_true <- data1$gamma
```

Description

Computes sparse vector autoregressive coefficients matrices of order 1 and order 2 and precision matrix estimates for time series chain graphical models using SCAD penalty. In time series chain graphs directed edges are identified by nonzero entries of the autoregressive coefficients matrix and undirected edges are identified by nonzero entries of the precision matrix.

Usage

```r
sparse.tscgm(data = data, lam1 = NULL, lam2 = NULL, nlambda = NULL,
              model = c("ar1", "ar2"), penalty = c("scad", "lasso"),
              optimality = c("NULL", "bic", "bic_ext", "bic_mod", "aic", "gic"),
              control = list())
```

Arguments

- data: Longitudinal data format.
- lam1: Either a scalar or a vector of tuning parameter values for the SCAD penalty on the precision matrix. The default is lam1=NULL and the program generates a sequence of tuning parameter values based on nlambda. The user can also specify a sequence to change the default sequence. If lam1 is a vector with length at least 2, information criteria based model selection will be performed to select the optimal tuning parameter.
Either a scalar or a vector of tuning parameter values for the SCAD penalty on the precision matrix. The default is `lam2=NULL` and the program generates a sequence of tuning parameter values based on `nlambda`. The user can also specify a sequence to chance the default sequence. If `lam2` is a vector with length at least 2, information criteria based model selection will be performed to select the optimal tuning parameter.

The number of values used in `lam1` and `lam2`. Default value is 10.

This specifies the order of vector autoregressive models. Vector autoregressive model of order 1 is applied if `model = "ar1"` and Vector autoregressive model of order 2 is applied if `method = "ar2"`.

This specifies the type of penalty function to be used. SCAD penalty function is applied if `penalty = "scad"` and GLASSO is applied if `penalty = "lasso"`.

This specifies the type of information based model selection criteria. When optimality is "NULL" it computes the time series chain graphical model solutions for specified scalar values of the tuning parameters `lam1` and `lam2`. The rest optimality criteria first selects the optimal SCAD tuning parameter values using the minimum information criterion from vectors of tuning parameters for `lam1` and `lam2` then computes the time series chain graphical model solutions based on the optimal tuning parameter values. These are: "BIC" (Bayesian Information Criteria), "bic_ext" (Extended Bayesian Information Criteria), "bic_mod" (Modified Bayesian Information Criteria) "aic" (Akakie Information Criteria), and "gic" (Generalized Information Criteria).

The argument `control` includes a list of control parameters passed to the main function. The user can specify its own control parameter values to replace the default values.

```r
control = list(maxit.out = 5, maxit.in = 50, tol.out = 1e-04, silent = TRUE)
```

- `maxit.out`: The maximum allowable outer iterations of the algorithm. The outer-loop iterates alternatively to estimate the precision matrix and the autoregression matrix until convergence. Default is 5.
- `maxit.in`: The maximum allowable iterations of the algorithm that minimizes with respect to the autoregression coefficient matrix. Default is 50.
- `tol.out`: Convergence tolerance for outer-loop of the algorithm that alternate between the estimation of precision matrix and autoregressive coefficients matrix. Default is 1e-04.
- `silent`: Either TRUE or FALSE. If `silent=FALSE` this function will display progress updates to the screen. Default is TRUE.

**Details**

For description of the objective functions and computational details see Abegaz and Wit (2013).

**Value**

A list containing:

- `theta`: Precision matrix estimate. The nonzero estimates of the precision matrix are used for constructing undirected graphs that represent conditional independences at time lag 0 or instantaneous interactions.
gamma

Autoregressive coefficients matrix estimate. The nonzero estimates of the autoregression matrix are used for constructing directed graphs that represent conditional independences at time lag 1, time lag 2 or dynamic interactions.

lam1.opt

The optimal tuning parameter for SCAD penalty on the precision matrix selected with minimum information criterion.

lam2.opt

The optimal tuning parameter for SCAD penalty on the autoregressive coefficients matrix selected with minimum BIC criterion.

min.ic

Minimum value of the optimality criterion.

tun.ic

A matrix containing the list of tuning parameter values and the corresponding model selection or optimality values.

lam1.seq

The sequence of tuning parameter values related to precision matrix.

lam2.seq

The sequence of tuning parameter values related to autoregression matrix.

s.theta

Sparsity level of the precision matrix.

s.gamma

Sparsity level of the autoregression coefficients matrix.

Author(s)

Fentaw Abegaz and Ernst Wit

References


Examples

```
seed = 321
datas <- sim.data(model="ar1", time=10,n.obs=10, n.var=5, seed=seed, prob0=0.35, network="random")
data.fit <- datas$data1
prec_true <- datas$theta
autoR_true <- datas$gamma

res.tscgm <- sparse.tscgm(data=data.fit, lam1=NULL, lam2=NULL, nlambda=NULL, model="ar1", penalty="scad", optimality="bic_mod", control=list(maxit.out = 10, maxit.in = 100))

#Estimated sparse precision and autoregression matrices
prec <- res.tscgm$theta
autoR <- res.tscgm$gamma

#Optimal tuning parameter values
lambda1.opt <- res.tscgm$lam1.opt
lambda2.opt <- res.tscgm$lam2.opt
```
# Sparsity levels
sparsity_theta <- res.tscgm$s.theta
sparsity_gamma <- res.tscgm$s.gamma

# Graphical visualization
oldpar <- par(mfrow=c(2,2))
plot.tscgm(datas, mat="precision",main="True precision matrix")
plot.tscgm(res.tscgm, mat="precision",main="Estimated precision matrix")
plot.tscgm(datas, mat="autoregression",main="True autoregression coef. matrix")
plot.tscgm(res.tscgm, mat="autoregression",
main="Estimated autoregression coef. matrix")
par(oldpar)

summary.tscgm

---

**summary.tscgm**  
*Summary - S3 Method for Class 'sparse.tscgm'*

### Description

`summary` is a generic function that produces output summaries of fitted models in the SparseTSCGM package. In particular, the function invokes methods for objects of class `sparse.tscgm`.

### Usage

```r
## S3 method for class 'tscgm'
summary(object, ...)
```

### Arguments

- **object**: An object of class `sparse.tscgm`
- **...**: Other arguments passed to `summary`.

### Details

The `summary.tscgm` function provides summary results of the fitted model.

### Value

A list containing:

- **theta**: Precision matrix estimate
- **gamma**: Autoregressive coefficients matrix estimate
- **lam1.opt**: The optimal tuning parameter on the precision matrix with model selection.
- **lam2.opt**: The optimal tuning parameter on the autoregressive coefficients matrix with model selection.
- **min.ic**: Minimum value of the optimality criterion.
- **tun.ic**: A matrix containing the list values from model selection.
The sequence of tuning parameter values on precision matrix.
The sequence of tuning parameter values on autoregression matrix.
Sparsity level of the precision matrix.
Sparsity level of the autoregression coefficients matrix.

Author(s)
Fentaw Abegaz and Ernst Wit

See Also
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