Package 'DIFM'

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Type Package

Title Dynamic ICAR Spatiotemporal Factor Models

Version 1.0

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Description Bayesian factor models are effective tools for dimension reduction. This is especially applicable to multivariate large-scale datasets. It allows researchers to understand the latent factors of the data which are the linear or non-linear combination of the variables. Dynamic Intrinsic Conditional Autocorrelative Priors (ICAR) Spatiotemporal Factor Models 'DIFM' package provides function to run Markov Chain Monte Carlo (MCMC), evaluation methods and visual plots from Shin and Ferreira (2023)<doi:10.1016/j.spasta.2023.100763>. Our method is a class of Bayesian factor model which can account for spatial and temporal correlations. By incorporating these correlations, the model can capture specific behaviors and provide predictions.

License GPL (>= 2)

Imports Rcpp (>= 1.0.10), Matrix, LaplacesDemon, spdep, gridExtra, sp

LinkingTo Rcpp, RcppArmadillo

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Encoding UTF-8

Depends R (>= 2.10)

LazyData true

Suggests knitr, rmarkdown, testthat (>= 3.0.0)

VignetteBuilder knitr

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NeedsCompilation yes

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Contents

`DIFM-package` *Dynamic ICAR Spatiotemporal Factor Models*

Description

Bayesian factor models are effective tools for dimension reduction. This is especially applicable to multivariate large-scale datasets. It allows researchers to understand the latent factors of the data which are the linear or non-linear combination of the variables. Dynamic Intrinsic Conditional Autocorrelative Priors (ICAR) Spatiotemporal Factor Models 'DIFM' package provides function to run Markov Chain Monte Carlo (MCMC), evaluation methods and visual plots from Shin and Ferreira (2023)<doi:10.1016/j.spasta.2023.100763>. Our method is a class of Bayesian factor model which can account for spatial and temporal correlations. By incorporating these correlations, the model can capture specific behaviors and provide predictions.

Details

Package: BCFM2

Type: Package

Version: 1.0

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Author(s)

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References

Shin, H. and Ferreira, M. (2023). "Dynamic ICAR Spatiotemporal Factor Models." Spatial Statistics, 56, 100763

Lopes, H. and West, M. (2004). "Bayesian Model Assessment in Factor Analysis." Statistica Sinica, 14, 41–67.

Prado, R., Ferreira, M. A. R., and West, M. (2021). Time Series: Modeling, Computation, and Inference. 2nd ed. Boca Raton: CRC Press.

`buildH` *Spatial dependence matrix of the factor loadings*

Description

It computes the spatial covariance and precision matrix of the neighboring subregions using Intrinsice Autoregressive Conditional (ICAR) process.

Usage

```
buildH(areapoly, permutation = NA)
```

Arguments

`areapoly`	The polygon of the areas. We can obtain this through `readOGR` function from `sp` matrix.
`permutation`	Permutation order of the subregions

Details

The off-digonal values are -1 when two subregions are neighbors. Otherwise, we assign 0. The diagonal values are the sum of the values of its own row.

Value

A list of two matrices: Precision matrix H and the covariance matrix obtained through Moore-Penrose inverse of H.

difm.hyp.parm *Hyperparameters for DIFM*

Description

Sets the hyperparameters to generate Gibbs sampler of DIFM

Usage

```
difm.hyp.parm(
  model.attributes,
  n.tau = 2.2,
  n.s2.tau = 0.1,
  n.sigma = 2.2,
  n.s2.sigma = 0.1,
  Hlist,
  Psi.size = 0.01
)
```

Arguments

model.attributes	Model attributes from difm.model.attributes
n.tau	Shape parameter for tau
n.s2.tau	Rate parameter for tau
n.sigma	Shape parameter for sigma squared
n.s2.sigma	Rate parameter for sigma squared
Hlist	Neighborhood matrix
Psi.size	The magnitude of covariance for the evolution matrix

Value

A list of hyperparameters of tau, W, sigma, and theta.

difm.model.attributes *Initialize model attributes for DIFM*

Description

It initialize the basic parameters and model attributes for DIFM

Usage

```
difm.model.attributes(data, n.iter, n.factors, G0)
```

Arguments

data	The dataset
n.iter	Number of iterations
n.factors	Number of factors to run DIFM
G0	The basic evolution matrix for one factor

Value

A list of number of timepoints, subregions, factors, matrix of evolution matrix, and matrix to extract common factors.

DIFMcpp *Run Dynamic ICAR Factors Model (DIFM), with C++ codes*

Description

This function runs Dynamic ICAR factors Model (DIFM), simulated from C++ codes

Usage

```
DIFMcpp(model.attributes, hyp.parm, data, every = 1, verbose = TRUE)
```

Arguments

model.attributes	Model attributes from difm.model.attributes
hyp.parm	Hyperparameters from difm.hyp.parm
data	The dataset
every	Save every iterations to final result
verbose	Print out the iteration process

Value

The Gibbs sampler of DIFM

DIFMR *Run Dynamic ICAR Factors Model (DIFM)*

Description

This function runs Dynamic ICAR factors Model (DIFM)

Usage

```
DIFMR(model.attributes, hyp.parm, data, every = 1, verbose = TRUE)
```

Arguments

model.attributes	Model attributes from difm.model.attributes
hyp.parm	Hyperparameters from difm.hyp.parm
data	The dataset
every	Save every iterations to final result
verbose	Print out the iteration process

Value

The Gibbs sampler of DIFM

marginal.d *Marginal predictive density*

Description

It calculates the marginal density (Lewis and Raftery, 1997) from the DIFM sample using R.

Usage

```
marginal.d(
  data,
  model.attributes,
  hyp.parm,
  Gibbs,
  burnin = NA,
  verbose = TRUE
)
```

Arguments

data	The dataset
model.attributes	Model attributes generated from difm.model.attributes.
hyp.parm	Hyperparameters generated from difm.hyp.parm.
Gibbs	Result of Gibbs sampler from DIFM function.
burnin	Burn-in period. If not specified, one tenths of the iterations will be the burn-in period.
verbose	Print out the iteration process.

Value

Metropolis-Laplace estimator of the Marginal density

---

marginal_d_cpp *Marginal predictive density*

Description

It calculates the marginal density (Lewis and Raftery, 1997) from the DIFM sample using C++.

Usage

```
marginal_d_cpp(data, attributes, hyp_parm, Gibbs, burnin = -1L, verbose = TRUE)
```

Arguments

data	The dataset
attributes	Model attributes generated from difm.model.attributes.
hyp_parm	Hyperparameters generated from difm.hyp.parm.
Gibbs	Result of Gibbs sampler from DIFM function.
burnin	Burn-in period. If not specified, one tenths of the iterations will be the burn-in period.
verbose	Print out the process.

Value

A list of 4 items: Laplace-Metropolis predictive density of the given DIFM, integrated likelihood, the maximum of the predictive densities and determinant of the covariance matrix of the parameters.

`permutation.order` *Order of permutation by the largest absolute value in each eigenvector*

Description

It finds the vector of permutation to permute data by its largest absolute value in each eigenvector. It sets the order by specified number of factors, and the rest is ordered as they were.

Usage

```
permutation.order(data, n.factors)
```

Arguments

`data`	The dataset
`n.factors`	Number of factors

Value

The numeric vector of permutation

`permutation.scale` *Permute the dataset by the largest absolute value in each eigenvector, and scale*

Description

It finds the vector of permutation to permute data by its largest absolute value in each eigenvector. It sets the order by specified number of factors, and the rest is ordered as they were. The data is permuted, and if needed, scaled.

Usage

```
permutation.scale(data, n.factors, return.scale = FALSE)
```

Arguments

`data`	The dataset
`n.factors`	Number of factors
`return.scale`	Scale data after permutation

Value

The permuted and standardized dataset, either in matrix or array.

plot_B.CI *Credible interval plot of factor loadings*

Description

The functions builds a column-wise plots of factor loadings. The parameters fixed at 1 are displayed with red dashed vertical lines.

Usage

```
plot_B.CI(
  Gibbs,
  true.val = NA,
  burnin = NA,
  permutation = NA,
  main.bool = TRUE,
  layout.dim = NA
)
```

Arguments

Gibbs	Result of Gibbs sampler from DIFM function
true.val	True values of factor loadings. If not available, NA.
burnin	Number of burn-in. If not specified, it uses the first tenths as burn-in period.
permutation	Permutation of variables. If not specified, no permutation.
main.bool	Add title of the plots.
layout.dim	Dimension of panel layout for multiple factor loadings. If not specificed, factor loadings plots are layout in one column.

Value

Factor loadings credible interval plots

plot_B.spatial *Spatial plots of factor loadings*

Description

The functions builds maps of factor loadings.

Usage

```
plot_B.spatial(
  Gibbs,
  areapoly,
  burnin = NA,
  permutation = NA,
  main.bool = TRUE,
  layout.dim = NA
)
```

Arguments

Gibbs	Result of Gibbs sampler from DIFM function.
areapoly	The polygon of the areas. We can obtain this through readOGR function from sp package.
burnin	Number of burn-in. If not specified, it uses the first tenths as burn-in period.
permutation	Permutation of variables. If not specified, no permutation.
main.bool	Add title of the plots.
layout.dim	Dimension of panel layout for multiple factor loadings. If not specificed, factor loadings plots are layout in one column.

Value

Factor loadings map plots

---

plot_sigma2.CI *A credible interval plot of posterior of sigma squared*

Description

It returns a credible interval plot of idiosyncratic variance, sigma squared. The lines are 95

Usage

```
plot_sigma2.CI(Gibbs, burnin = NA, permutation = NA, main.bool = TRUE)
```

Arguments

Gibbs	Result of Gibbs sampler from DIFM function.
burnin	Number of burn-in. If not specified, it uses the first tenths as burn-in period.
permutation	Permutation of variables. If not specified, no permutation.
main.bool	Add title of the plots.

Value

A credible interval plot of sigma squared

plot_tau.CI *Credible interval plot of factor loadings variance*

Description

It returns a credible interval plot of factor loadings covariance, tau. The lines are 95

Usage

```
plot_tau.CI(Gibbs, burnin = NA, true.val = NA, main.bool = TRUE)
```

Arguments

Gibbs	Result of Gibbs sampler from DIFM function.
burnin	Number of burn-in. If not specified, it uses the first tenths as burn-in period.
true.val	True values of tau. If not available, NA.
main.bool	Add title of the plots.

Value

Credible interval plot of tau

plot_X.CI *Credible interval plot of common factors*

Description

The functions builds the plot of 95% confidence intervals of the common realizations, X. The black solid lines are the posterior mean and the dased lines are the 95% confidence intervals.

Usage

```
plot_X.CI(Gibbs, burnin = NA, main.bool = FALSE, layout.dim = NA)
```

Arguments

Gibbs	Result of Gibbs sampler from DIFM function.
burnin	Number of burn-in. If not specified, it uses the first tenths as burn-in period.
main.bool	Add title of the plots.
layout.dim	Dimension of panel layout for multiple common factors. If not specificed, common factor plots are layout in one column.

Value

Credible interval plots of common factors

Property *Property crime in United States*

Description

A subset of data of property crime per 100,000 people in western states from 1960 to 2019.

Usage

```
Property
```

Format

'Property' A data frame with 60 rows and 11 columns:

AZ Arizona

CA California

CO Colorado

ID Idaho

MT Montana

NV Nevada

NM New Mexico

OR Oregon

UT Utah

WA Washington

WY Wyoming ...

Source

<https://www.disastercenter.com/crime/>

Violent *Violent crime data in United States*

Description

A subset of data of violent crime per 100,000 people in western states from 1960 to 2019.

Usage

```
Violent
```

Format

'Violent' A data frame with 60 rows and 11 columns:

AZ Arizona

CA California

CO Colorado

ID Idaho

MT Montana

NV Nevada

NM New Mexico

OR Oregon

UT Utah

WA Washington

WY Wyoming ...

Source

<https://www.disastercenter.com/crime/>

WestStates *Westen states in United States*

Description

A sp map data of the western states in United States

Usage

```
WestStates
```

Format

'WestStates' A SpatialPolygonsDataFrame data of the western states in United States

FID The number ID of the western states

State_Code Abbreviations of the state names

State_Name Names of the states A SpatialPolygonsDataFrame data of the western states in United States

Source

<https://www.census.gov/geographies/mapping-files/time-series/geo/carto-boundary-file.html>

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