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`bayesefa-package` *bayesefa: Bayesian Exploratory Factor*

Description

Exploratory Bayesian factor analysis of continuous, mixed-type, and bounded continuous variables using the mode-jumping algorithm of Man and Culpepper (2020) doi:10.1080/01621459.2020.1773833.

Author(s)

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References

Man, A. & Culpepper, S. A. (2020). A mode-jumping algorithm for Bayesian factor analysis. Journal of the American Statistical Association, doi:10.1080/01621459.2020.1773833.

`EFA_Mode_Jumper` *Exploratory Factor Analysis of Continuous Response Data*

Description

Implement the Man and Culpepper (2020) mode-jumping algorithm to factor analyze continuous response data.

Usage

```
EFA_Mode_Jumper(Y, M, gamma, burnin, chain_length = 10000L)
```

Arguments

Y	A N by J matrix of mean-centered, continuous variables.
M	An integer specifying the number of factors.
gamma	The value of the mode-jumping tuning parameter. Man and Culpepper (2020) used gamma = 0.5.
burnin	Number of burn-in iterations to discard.
chain_length	The total number of iterations (burn-in + post-burn-in).

Value

A list that contains nsamples = chain_length - burnin array draws from the posterior distribution:

- LAMBDA: A J by M by nsamples array of sampled loading matrices.
- PSIs: A J by nsamples matrix of vector of variable uniquenesses.
- ROW_OUT: A matrix of sampled row indices of founding variables for mode-jumping algorithm.
- F_OUT: An array of sampled factor scores.
- ACCEPTED: Acceptance rates for mode-jumping Metropolis-Hastings (MH) steps.

Author(s)

Steven Andrew Culpepper, Albert Man

References

Man, A. & Culpepper, S. A. (2020). A mode-jumping algorithm for Bayesian factor analysis. Journal of the American Statistical Association, doi:10.1080/01621459.2020.1773833.

Examples

```
data(exchangerate)

#Retain complete cases and drop Month_Year column
X<-exchangerate[complete.cases(exchangerate),-1]
X<-apply(X,2, diff)
X<-as.matrix(scale(X))

#Specify the number of factors
my_M<-2

#Run the mode-jumping EFA algorithm
burn_in<-150
chain_length<-300
out <- EFA_Mode_Jumper(X,my_M,gamma=0.5,burnin=burn_in,chain_length)

#Rotate all samples to permutation positive lower triangular (PPLT)
#structure with USD and FRF as factor founding variables
  my_lambda_sample = out$LAMBDA
    for (j in 1:dim(my_lambda_sample)[3]) {
```

```
    my_rotate = proposal2(c(1,4),my_lambda_sample[,,j],out$F_OUT[,,j])
    my_lambda_sample[,,j] = my_rotate$lambda
  }

#compute posterior mean of PPLT loadings
mLambda<-apply(my_lambda_sample,c(1,2),mean)
```

`exchangerate` *International Exchange Rate Dataset*

Description

This dataset was considered by West and Harrison (1997) and Lopes and West (2004). The dataset consists of n = 143 monthly first-differences of the exchange rates of 6 international currencies against the British pound, from Jan 1975 to Dec 1986, these currencies are: US dollar (USD), Canadian dollar (CAD), Japanese yen (JPY), French franc (FRF), German (deutsche) mark (DEM), and the Italian lira (ITL).

Usage

```
exchangerate
```

Format

A 143 by 7 `matrix` of exchange rate time-series. The variables include:

`Month_Year` Month and year of exchange rate data.

`USD` US dollar

`CAD` Canadian dollar

`JPY` Japanese yen

`FRF` French franc

`DEM` German (deutsche) mark

`ITL` Italian lira

Author(s)

Steven Culpepper

Source

Lopes, H. F., and West, M. (2004). Bayesian model assessment in factor analysis, Statistica Sinica, 14, 41–67.

Man, A. & Culpepper, S. A. (2020). A mode-jumping algorithm for Bayesian factor analysis. Journal of the American Statistical Association, doi:10.1080/01621459.2020.1773833.

West, M., and Harrison, J. (1997), Bayesian forecasting and dynamic models (2nd ed.), Berlin, Heidelberg: Springer-Verlag.

IFA_Mode_Jumper *Exploratory Item Factor Analysis for Ordinal Response Data*

Description

Implement the Man and Culpepper (2020) mode-jumping algorithm to factor analyze ordinal response data. Missing values should be specified as a non-numeric value such as NA.

Usage

```
IFA_Mode_Jumper(Y, M, gamma, Ms, sdMH, burnin, chain_length = 10000L)
```

Arguments

Y	A N by J matrix of item responses.
M	The number of factors.
gamma	Mode-jumping tuning parameter. Man & Culpepper used 0.5.
Ms	A vector of the number of score categories. Note 2 = two parameter normal ogive, >2 ordinal normal ogive.
sdMH	A vector of tuning parameters of length J for implementing the Cowles (1996) Metropolis-Hastings threshold sampler.
burnin	Number of burn-in iterations to discard.
chain_length	The total number of iterations (burn-in + post-burn-in).

Value

A list that contains nsamples = chain_length - burnin array draws from the posterior distribution:

- LAMBDA: A J by M by nsamples array of sampled loading matrices on the standardized metric.
- PSIs: A J by nsamples matrix of vector of variable uniquenesses on the standardized metric.
- ROW_OUT: A matrix of sampled row indices of founding variables for mode-jumping algorithm.
- THRESHOLDS: An array of sampled thresholds.
- INTERCEPTS: Sampled variable thresholds on the standardized metric.
- ACCEPTED: Acceptance rates for mode-jumping Metropolis-Hastings (MH) steps.
- MHACCEPT: A J vector of acceptance rates for item threshold parameters. Note that binary items have an acceptance rate of zero, because MH steps are never performed.

Author(s)

Albert X Man, Steven Andrew Culpepper

References

Cowles, M. K. (1996), Accelerating Monte Carlo Markov chain convergence for cumulative link generalized linear models," Statistics and Computing, 6, 101-111.

Man, A. & Culpepper, S. A. (2020). A mode-jumping algorithm for Bayesian factor analysis. Journal of the American Statistical Association, doi:10.1080/01621459.2020.1773833.

`IFA_Mode_Jumper_MixedResponses`

Exploratory Factor Analysis of Mixed-Type Responses

Description

Implement the Man and Culpepper (2020) mode-jumping algorithm to factor analyze mixed-type response data. Missing values should be specified as a non-numeric value such as NA.

Usage

```
IFA_Mode_Jumper_MixedResponses(
  Y,
  M,
  gamma,
  Ms,
  sdMH,
  bounds,
  burnin,
  chain_length = 10000L
)
```

Arguments

`Y`	A N by J matrix of mixed-type item responses.
`M`	An interger specifying the number of factors.
`gamma`	The value of the mode-jumping tuning parameter. Man and Culpepper (2020) used gamma = 0.5.
`Ms`	model indicator where 0 = "bounded", 1 = "continuous", 2 = "binary", >2 = "ordinal".
`sdMH`	A J vector of tuning parameters for the Cowles (1996) Metropolis-Hastings sampler for ordinal data latent thresholds.
`bounds`	A J by 2 matrix denoting the min and max variable values. Note that bounds are only used for variable j if element j of Ms is zero.
`burnin`	Number of burn-in iterations to discard.
`chain_length`	The total number of iterations (burn-in + post-burn-in).

Value

A list that contains nsamples = chain_length - burnin array draws from the posterior distribution:

- `LAMBDA`: A J by M by nsamples array of sampled loading matrices on the standardized metric.
- `PSIs`: A J by nsamples matrix of vector of variable uniquenesses on the standardized metric.
- `ROW_OUT`: A matrix of sampled row indices of founding variables for mode-jumping algorithm.
- `THRESHOLDS`: An array of sampled thresholds.
- `INTERCEPTS`: Sampled variable thresholds on the standardized metric.
- `ACCEPTED`: Acceptance rates for mode-jumping Metropolis-Hastings (MH) steps.
- `MHACCEPT`: A J vector of acceptance rates for item threshold parameters. Note that binary items have an acceptance rate of zero, because MH steps are never performed.
- `LAMBDA_unst`: An array of unstandardized loadings.
- `PSIs_inv_unst`: A matrix of unstandardized uniquenesses.
- `THRESHOLDS_unst`: Unstandardized thresholds.
- `INTERCEPTS_unst`: Unstandardized intercepts.

Author(s)

Albert X Man, Steven Andrew Culpepper

References

Cowles, M. K. (1996), Accelerating Monte Carlo Markov chain convergence for cumulative link generalized linear models," Statistics and Computing, 6, 101-111.

Man, A. & Culpepper, S. A. (2020). A mode-jumping algorithm for Bayesian factor analysis. Journal of the American Statistical Association, doi:10.1080/01621459.2020.1773833.

`min2LL_ono` *Compute Deviance for Ordinal Probit Factor Model*

Description

Internal function to compute -2LL using unstandardized parameters.

Usage

```
min2LL_ono(N, J, Y, MISS, as, bs, theta, Ms, Kaps)
```

Arguments

N	The number of observations. (> 0)
J	The number of items. (> 0)
Y	A N by J matrix of item responses.
MISS	A N by J matrix of missing data indicators.
as	A matrix of item loadings.
bs	A vector of threshold parameters.
theta	A matrix of factor scores.
Ms	A vector of the number of score categories. Note 2 = two parameter normal ogive, >2 ordinal normal ogive.
Kaps	A matrix of category thresholds.

Value

-2LL.

Author(s)

Steven Andrew Culpepper

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mixedresponse_posterior_prediction

Posterior Predictions of Item Factor Analysis with Mixed Response Types

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Description

Generate posterior predictions for new variables using posterior samples.

Usage

```
mixedresponse_posterior_prediction(
  OUTPUT,
  Y,
  Ms,
  variable_predict_flag,
  bounds,
  n_mcmc_iterations = 10L
)
```

Arguments

OUTPUT	A list of output from IFA_Mode_Jumper_MixedResponses.
Y	A N by J matrix of item responses for predictions. Variables to predict are indicated in Y by NAs.
Ms	model indicator where 0 = "bounded", 1 = "continuous", 2 = "binary", >2 = "ordinal".
variable_predict_flag	A J vector. 0 = do not predict the variable; 1 = predict the variable.
bounds	A J by 2 matrix denoting the min and max variable values. Note that bounds are only used for variable j if element j of Ms is zero.
n_mcmc_iterations	The number of Gibbs iterations for sampling posterior predictions for factor scores and missing data. The default is 10 iterations.

Value

array of predictions for all posterior samples provided in OUTPUT.

Author(s)

Steven Andrew Culpepper

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proposal2 *Rotate loadings and factor scores to a permuted positive lower triangle*

Description

Rotates loading matrix according to specified founding variable row indices.

Usage

```
proposal2(new_r_idx, lambda, factors)
```

Arguments

new_r_idx	vector of row indices of length equal to the number of factors.
lambda	Loading matrix.
factors	A n x m matrix of factor scores that is rotated.

Value

A list of rotated loadings and factors.

Author(s)

Albert X Man

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