

Package ‘fourPNO’

December 16, 2015

Type Package

Title Bayesian 4 Parameter Item Response Model

Version 1.0.3

Date 2015-11-12

Description Estimate Barton & Lord's four parameter IRT model with lower and upper asymptotes using Bayesian formulation described by Culpepper (2015).

License GPL (>= 2)

Imports Rcpp

LinkingTo Rcpp, RcppArmadillo

Depends R (>= 3.0.1)

Author Steven Andrew Culpepper [aut, cre]

Maintainer Steven Andrew Culpepper <sculpepp@illinois.edu>

NeedsCompilation yes

Repository CRAN

Date/Publication 2015-12-16 16:09:35

R topics documented:

Gibbs_2PNO	2
Gibbs_4PNO	3
kappa_initialize	5
min2LL_4pno	5
rmvnorm	6
Total_Tabulate	7
update_2pno	7
update_ab_NA	8
update_ab_norestriction	9
update_theta	10
update_WKappaZ_NA	11
Y_4pno_simulate	12

Index	13
--------------	-----------

Gibbs_2PNO

*Gibbs Implementation of 2PNO***Description**

Internal function to -2LL

Usage

```
Gibbs_2PNO(Y,mu_xi,Sigma_xi_inv,mu_theta,Sigma_theta_inv,burnin,chain_length=10000L)
```

Arguments

Y	A N by J matrix of item responses.
mu_xi	A two dimensional vector of prior item parameter means.
Sigma_xi_inv	A two dimensional matrix of prior for the inverse item parameter variance-covariance matrix.
mu_theta	The prior mean for theta.
Sigma_theta_inv	The prior inverse variance for theta.
burnin	The number of MCMC samples to discard. Note that if burnin < chain_length that
chain_length	The number of MCMC samples.

Value

Samples from posterior.

Author(s)

Steven Andrew Culpepper

Examples

```
require(fourPNO)
#simulate small 2PNO dataset to demonstrate function
J = 5
N = 100
#population item parameters
as_t = rnorm(J,mean=2,sd=.5)
bs_t = rnorm(J,mean=0,sd=.5)
#sampling gs and ss with truncation
gs_t = rbeta(J,1,8)
ps_g = pbeta(1-gs_t,1,8)
ss_t = qbeta(runif(J)*ps_g,1,8)
theta_t <- rnorm(N)
Y_t = Y_4pno_simulate(N,J,as=as_t,bs=bs_t,gs=gs_t,ss=ss_t,theta=theta_t)
```

```

#setting prior parameters
mu_theta=0
Sigma_theta_inv=1
mu_xi = c(0,0)
alpha_c=alpha_s=beta_c=beta_s=1
Sigma_xi_inv = solve(2*matrix(c(1,0,0,1),2,2))
burnin = 1000
#Execute Gibbs sampler. This should take about 15.5 minutes
out_t <- Gibbs_4PNO(Y_t,mu_xi,Sigma_xi_inv,mu_theta,Sigma_theta_inv,alpha_c,beta_c,alpha_s,
                    beta_s,burnin,rep(1,J),rep(1,J),gwg_reps=5,chain_length=burnin*2)

#summarizing posterior distribution
OUT = cbind(apply(out_t$AS[-c(1:burnin)],1,mean),apply(out_t$BS[-c(1:burnin)],1,mean),
            apply(out_t$GS[-c(1:burnin)],1,mean),apply(out_t$SS[-c(1:burnin)],1,mean),
            apply(out_t$AS[-c(1:burnin)],1,sd),apply(out_t$BS[-c(1:burnin)],1,sd),
            apply(out_t$GS[-c(1:burnin)],1,sd),apply(out_t$SS[-c(1:burnin)],1,sd) )
OUT = cbind(1:J,OUT)
colnames(OUT) = c('Item','as','bs','gs','ss','as_sd','bs_sd','gs_sd','ss_sd')
print(OUT,digits=3)

```

Gibbs_4PNO

Gibbs Implementation of 4PNO

Description

Internal function to -2LL

Usage

```
Gibbs_4PNO(Y, mu_xi, Sigma_xi_inv, mu_theta, Sigma_theta_inv, alpha_c, beta_c,
            alpha_s, beta_s, burnin, cTF, sTF, gwg_reps, chain_length = 10000L)
```

Arguments

Y	A N by J matrix of item responses.
mu_xi	A two dimensional vector of prior item parameter means.
Sigma_xi_inv	A two dimensional matrix of prior for the inverse item parameter variance-covariance matrix.
mu_theta	The prior mean for theta.
Sigma_theta_inv	The prior inverse variance for theta.
alpha_c	The lower asymptote prior 'a' parameter.
beta_c	The lower asymptote prior 'b' parameter.
alpha_s	The upper asymptote prior 'a' parameter.
beta_s	The upper asymptote prior 'b' parameter.

burnin	The number of MCMC samples to discard. Note that if burnin < chain_length that
cTF	A J dimensional vector indicating which lower asymptotes to estimate. 0 = exclude lower asymptote and 1 = include lower asymptote.
sTF	A J dimensional vector indicating which upper asymptotes to estimate. 0 = exclude upper asymptote and 1 = include upper asymptote.
gwg_reps	The number of Gibbs within Gibbs MCMC samples for marginal distribution of gamma. Values between 5 to 10 are adequate.
chain_length	The number of MCMC samples.

Value

Samples from posterior.

Author(s)

Steven Andrew Culpepper

Examples

```
require(fourPNO)
#simulate small 4PNO dataset to demonstrate function
J = 5
N = 100
#population item parameters
as_t = rnorm(J,mean=2,sd=.5)
bs_t = rnorm(J,mean=0,sd=.5)
#sampling gs and ss with truncation
gs_t = rbeta(J,1,8)
ps_g = pbeta(1-gs_t,1,8)
ss_t = qbeta(runif(J)*ps_g,1,8)
theta_t <- rnorm(N)
Y_t = Y_4pno_simulate(N,J,as=as_t,bs=bs_t,gs=gs_t,ss=ss_t,theta=theta_t)

#setting prior parameters
mu_theta=0
Sigma_theta_inv=1
mu_xi = c(0,0)
alpha_c=alpha_s=beta_c=beta_s=1
Sigma_xi_inv = solve(2*matrix(c(1,0,0,1),2,2))
burnin = 1000
#Execute Gibbs sampler
out_t <- Gibbs_4PNO(Y_t,mu_xi,Sigma_xi_inv,mu_theta,Sigma_theta_inv,alpha_c,beta_c,alpha_s,
                    beta_s,burnin,rep(1,J),rep(1,J),gwg_reps=5,chain_length=burnin*2)

#summarizing posterior distribution
OUT = cbind(apply(out_t$AS[,-c(1:burnin)],1,mean),apply(out_t$BS[,-c(1:burnin)],1,mean),
            apply(out_t$GS[,-c(1:burnin)],1,mean),apply(out_t$SS[,-c(1:burnin)],1,mean),
            apply(out_t$AS[,-c(1:burnin)],1,sd),apply(out_t$BS[,-c(1:burnin)],1,sd),
            apply(out_t$GS[,-c(1:burnin)],1,sd),apply(out_t$SS[,-c(1:burnin)],1,sd) )
OUT = cbind(1:J,OUT)
```

```
colnames(OUT) = c('Item', 'as', 'bs', 'gs', 'ss', 'as_sd', 'bs_sd', 'gs_sd', 'ss_sd')
print(OUT, digits=3)
```

kappa_initialize *Initialize Thresholds*

Description

Internal function for initializing item thresholds.

Usage

```
kappa_initialize(Ms)
```

Arguments

Ms A vector with the number of scale values.

Value

A matrix that is a Multivariate Normal distribution

Author(s)

Steven Andrew Culpepper

See Also

[Gibbs_4PNO](#)

min2LL_4pno *Compute 4PNO Deviance*

Description

Internal function to compute the deviance, or minus 2 log-likelihood, -2LL.

Usage

```
min2LL_4pno(N, J, Y, as, bs, gs, ss, theta)
```

Arguments

N	An int, which gives the number of observations. (> 0)
J	An int, which gives the number of items. (> 0)
Y	A N by J matrix of item responses.
as	A vector of item discrimination parameters.
bs	A vector of item threshold parameters.
gs	A vector of item lower asymptote parameters.
ss	A vector of item upper asymptote parameters.
theta	A vector of prior thetas.

Value

-2LL.

Author(s)

Steven Andrew Culpepper

See Also

[Gibbs_4PNO](#)

rmvnorm

Generate Random Multivariate Normal Distribution

Description

Creates a random Multivariate Normal when given number of obs, mean, and sigma.

Usage

```
rmvnorm(n, mu, sigma)
```

Arguments

n	An int, which gives the number of observations. (> 0)
mu	A vector length m that represents the means of the normals.
sigma	A matrix with dimensions m x m that provides the covariance matrix.

Value

A matrix that is a Multivariate Normal distribution

Author(s)

James J Balamuta

Examples

```
#Call with the following data:
rmvnorm(2, c(0,0), diag(2))
```

Total_Tabulate	<i>Calculate Tabulated Total Scores</i>
----------------	---

Description

Internal function to -2LL

Usage

```
Total_Tabulate(N, J, Y)
```

Arguments

N	An int, which gives the number of observations. (> 0)
J	An int, which gives the number of items. (> 0)
Y	A N by J matrix of item responses.

Value

A vector of tabulated total scores.

Author(s)

Steven Andrew Culpepper

See Also

[Gibbs_4PNO](#)

update_2pno	<i>Update 2PNO Model Parameters</i>
-------------	-------------------------------------

Description

Internal function to update 2PNO model parameters

Usage

```
update_2pno(N, J, Y, Z, as, bs, theta, Kaps, mu_xi, Sigma_xi_inv, mu_theta, Sigma_theta_inv)
```

Arguments

N	The number of observations.
J	The number of items.
Y	A N by J matrix of item responses.
Z	A matrix N by J of continuous augmented data.
as	A vector of item discrimination parameters.
bs	A vector of item threshold parameters.
theta	A vector of prior thetas.
Kaps	A matrix for item thresholds (used for internal computations).
mu_xi	Prior mean for item parameters.
Sigma_xi_inv	Prior item parameter inverse variance-covariance matrix.
mu_theta	Prior mean for theta.
Sigma_theta_inv	Prior inverse variance for theta.

Value

A list of 2PNO model parameters.

Author(s)

Steven Andrew Culpepper

See Also

[Gibbs_4PNO](#)

update_ab_NA

Update a and b Parameters of 2PNO, 3PNO, 4PNO

Description

Update item slope and threshold

Usage

update_ab_NA(N, J, Z, as, bs, theta, mu_xi, Sigma_xi_inv)

Arguments

N	An int, which gives the number of observations. (> 0)
J	An int, which gives the number of items. (> 0)
Z	A matrix N by J of continuous augmented data.
as	A vector of item discrimination parameters.
bs	A vector of item threshold parameters.
theta	A vector of prior thetas.
mu_xi	A two dimensional vector of prior item parameter means.
Sigma_xi_inv	A two dimensional identity matrix of prior item parameter VC matrix.

Value

A list of item parameters.

Author(s)

Steven Andrew Culpepper

See Also

[Gibbs_4PNO](#)

update_ab_norestriction

Update a and b Parameters of 4pno without alpha > 0 Restriction

Description

Update item slope and threshold

Usage

update_ab_norestriction(N, J, Z, as, bs, theta, mu_xi, Sigma_xi_inv)

Arguments

N	An int, which gives the number of observations. (> 0)
J	An int, which gives the number of items. (> 0)
Z	A matrix N by J of continuous augmented data.
as	A vector of item discrimination parameters.
bs	A vector of item threshold parameters.
theta	A vector of prior thetas.
mu_xi	A two dimensional vector of prior item parameter means.
Sigma_xi_inv	A two dimensional identity matrix of prior item parameter VC matrix.

Value

A list of item parameters.

Author(s)

Steven Andrew Culpepper

See Also

[Gibbs_4PN0](#)

update_theta

Internal Function for Updating Theta in Gibbs Sampler

Description

Update theta in Gibbs sampler

Usage

```
update_theta(N, Z, as, bs, theta, mu_theta, Sigma_theta_inv)
```

Arguments

N	An int, which gives the number of observations. (> 0)
Z	A matrix N by J of continuous augmented data.
as	A vector of item discrimination parameters.
bs	A vector of item threshold parameters.
theta	A vector of prior thetas.
mu_theta	The prior mean for theta.
Sigma_theta_inv	The prior inverse variance for theta.

Value

A vector of thetas.

Author(s)

Steven Andrew Culpepper

See Also

[Gibbs_4PN0](#)

update_WKappaZ_NA *Update Lower and Upper Asymptote Parameters of 4PNO*

Description

Internal function to update item lower and upper asymptote

Usage

```
update_WKappaZ_NA(Y, Ysum, Z, as, bs, gs, ss, theta, Kaps, alpha_c, beta_c,  
alpha_s, beta_s, gwg_reps)
```

Arguments

Y	A N by J matrix of item responses.
Ysum	A vector of item total scores.
Z	A matrix N by J of continuous augmented data.
as	A vector of item discrimination parameters.
bs	A vector of item threshold parameters.
gs	A vector of item lower asymptote parameters.
ss	A vector of item upper asymptote parameters.
theta	A vector of prior thetas.
Kaps	A matrix for item thresholds (used for internal computations).
alpha_c	The lower asymptote prior 'a' parameter.
beta_c	The lower asymptote prior 'b' parameter.
alpha_s	The upper asymptote prior 'a' parameter.
beta_s	The upper asymptote prior 'b' parameter.
gwg_reps	The number of Gibbs within Gibbs MCMC samples for marginal distribution of gamma.

Value

A list of item threshold parameters.

Author(s)

Steven Andrew Culpepper

See Also

[Gibbs_4PNO](#)

Y_4pno_simulate *Simulate from 4PNO Model*

Description

Generate item responses under the 4PNO

Usage

```
Y_4pno_simulate(N, J, as, bs, gs, ss, theta)
```

Arguments

N	An int, which gives the number of observations. (> 0)
J	An int, which gives the number of items. (> 0)
as	A vector of item discrimination parameters.
bs	A vector of item threshold parameters.
gs	A vector of item lower asymptote parameters.
ss	A vector of item upper asymptote parameters.
theta	A vector of prior thetas.

Value

A N by J matrix of dichotomous item responses.

Author(s)

Steven Andrew Culpepper

See Also

[Gibbs_4PNO](#)

Index

Gibbs_2PNO, [2](#)

Gibbs_4PNO, [3](#), [5–12](#)

kappa_initialize, [5](#)

min2LL_4pno, [5](#)

rmvnorm, [6](#)

Total_Tabulate, [7](#)

update_2pno, [7](#)

update_ab_NA, [8](#)

update_ab_norestriction, [9](#)

update_theta, [10](#)

update_WKappaZ_NA, [11](#)

Y_4pno_simulate, [12](#)