Package 'POET'

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Description Estimate large covariance matrices in approximate factor models by thresholding principal orthogonal complements.

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`POET` *Principal Orthogonal ComplEment Thresholding (POET) method*

Description

Estimates large covariance matrices in approximate factor models by thresholding principal orthogonal complements.

Usage

```
POET(Y, K, C, thres, matrix)
```

Arguments

`Y` p by n matrix of raw data, where p is the dimensionality, n is the sample size. It is recommended that Y is de-meaned, i.e., each row has zero mean.

`K` number of factors. K is pre-determined by the users. Default value is set at the average value obtained from the Hallin&Liska and Bai&Ng methods. Suggestions on choosing K:

A simple way of determining K is to count the number of very spiked (much larger than others) eigenvalues of the p by p sample covariance matrix of Y.

A formal data-driven way of determining K is described in Bai and Ng (2002):"Determining the number of factors in approximate factor models", Econometrica, 70, 191-221. This procedure requires a one-dimensional optimization.

POET is very robust to over-estimating K. But under-estimating K can result to VERY BAD performance. Therefore we strongly recommend choosing a relatively large K (normally less than 8) to avoid missing any important common factor.

K=0 corresponds to threshoding the sample covariance directly.

`C` the positive constant for thresholding, user-specified. Default value is set at C=0.5 Our experience shows that C=0.5 performs quite well for soft thresholding.

`thres` choice of thresholding. Users can choose from three thresholding methods:

'soft': soft thresholding

'hard' hard thresholding

'scad': scad thresholding

'alasso': adaptive lasso thresholding

Default value is set at thres='soft'.

Details are found in Rothman et al. (2009): "Generalized thresholding of large covariance matrices." JASA, 104, 177-186

`matrix` the option of thresholding either correlation or covairance matrix. Users can choose from:

'cor': threshold the error correlation matrix then transform back to covariance matrix

'vad': threshold the error covariance matrix directly.

Default value is set at matrix='cor'.

Details

This function is for POET, proposed by Fan, Liao and Mincheva (2012) "Large Covariance Estimation by Thresholding Principal Orthogonal Complements", manuscript of Princeton University

Model: Y_t=Bf_t+u_t, where B, f_t and u_t represent factor loading matrix, common factors and idiosyncratic error respectively. Only Y_t is observable. t=1,...,n. Dimension of Y_t is p. The goal is to estimate the covariance matrices of Y_t and u_t.

Note: (1) POET is optimization-free, so no initial value, tolerant, or maximum iterations need to be specified as inputs.

(2) We can apply the adaptive thresholding (Cai and Liu 2011, JASA) on either the correlation matrix or the covariance matrix, specified by the option 'matrix'.

(3) If no factor structure is assumed, i.e., no common factors exist and var(Y_t) itself is sparse, set K=0.

Value

`SigmaY:`	estimated p by p covariance matrix of y_t
`SigmaU:`	estimated p by p covariance matrix of u_t
`factors:`	estimated unobservable factors in a K by T matrix form
`loadings:`	estimated factor loadings in a p by K matrix form

Author(s)

Jianqing Fan, Yuan Liao, Martina Mincheva

References

Fan, Liao and Mincheva (2012) "Large Covariance Estimation in Approximate Factor Models by Thresholding Principal Orthogonal Complements", manuscript of Princeton University, arXiv: 1201.0175

Examples

```
p=100
n=100
Y<-array(rnorm(p*n),dim=c(p,n))
Sy<-POET(Y,3,0.5,'soft','vad')$SigmaY
Su<-POET(Y,3,0.5,'soft','vad')$SigmaU
F<-POET(Y,3,0.5,'soft','vad')$factors
B<-POET(Y,3,0.5,'soft','vad')$loadings
```

`POETCmin` *Cmin - Minimum threshold constant*

Description

This function is for determining the minimum constant in the threshold that guarantees the positive definiteness of the POET estimator.

Usage

```
POETCmin(Y, K, thres, matrix)
```

Arguments

`Y`	p by n matrix of raw data, where p is the dimensionality, n is the sample size. It is recommended that Y is de-meaned, i.e., each row has zero mean.
`K`	number of factors. K is pre-determined by the users. Suggestions on choosing K: (1) A simple way of determining K is to count the number of very spiked (much larger than others) eigenvalues of the p by p sample covariance matrix of Y. (2) A formal data-driven way of determining K is described in Bai and Ng (2002):"Determining the number of factors in approximate factor models", Econometrica, 70, 191-221. This procedure requires a one-dimensional optimization. (3) POET is very robust to over-estimating K. But under-estimating K can result to VERY BAD performance. Therefore we strongly recommend choosing a relatively large K (normally less than 8) to avoid missing any important common factor. (4) K=0 corresponds to threshoding the sample covariance directly.
`thres`	choice of thresholding. Users can choose from three thresholding methods: 'soft': soft thresholding 'hard': hard thresholding 'scad': scad thresholding 'alasso': adaptive lasso thresholding Details are found in Rothman et al. (2009): "Generalized thresholding of large covariance matrices." JASA, 104, 177-186
`matrix`	the option of thresholding either correlation or covairance matrix. Users can choose from: 'cor': threshold the error correlation matrix then transform back to covariance matrix 'vad': threshold the error covariance matrix directly.

Details

Model: Y_t=Bf_t+u_t, where B, f_t and u_t represent factor loading matrix, common factors and idiosyncratic error respectively. Only Y_t is observable. t=1,...,n. Dimension of Y_t is p. The goal is to estimate the covariance matrices of Y_t and u_t.

Note: (1) POET is optimization-free, so no initial value, tolerant, or maximum iterations need to be specified as inputs.

(2) We can apply the adaptive thresholding (Cai and Liu 2011, JASA) on either the correlation matrix or the covariance matrix, specified by the option 'matrix'.

(3) If no factor structure is assumed, i.e., no common factors exist and var(Y_t) itself is sparse, set K=0.

Value

Outputs:

`SigmaY:`	estimated p by p covariance matrix of y_t
`SigmaU:`	estimated p by p covariance matrix of u_t

Author(s)

Jianqing Fan, Yuan Liao, Martina Mincheva

References

Fan, Liao and Mincheva (2012) "Large Covariance Estimation in Approximate Factor Models by Thresholding Principal Orthogonal Complements", manuscript of Princeton University, arXiv: 1201.0175

Examples

```
p=100
n=50
Y<-array(rnorm(p*n),dim=c(p,n))
C<-POETCmin(Y,3,'soft','vad')
```

`POETKhat` *Khat - number of factors in approximate factor model*

Description

This function is for calculating the optimal number of factors in an approximate factor model.

Usage

```
POETKhat(Y)
```

Arguments

`Y`	p by n matrix of raw data, where p is the dimensionality, n is the sample size. It is recommended that Y is de-meaned, i.e., each row has zero mean.

Details

This method was proposed by Bai & Ng (2002) and Hallin & Liska (2007). They propose two penalty functions and in turn minimize the corresponding information criteria. Notice that this method may underestimate K. POET is very robust to over-estimating K. But under-estimating K can result to VERY BAD performance. Therefore we strongly recommend choosing a relatively large K (normally less than 8) to avoid missing any important common factor.

Value

`K1HL`	estimated number of factors based on the first infomation criterion using Hallin & Liska method
`K2HL`	estimated number of factors based on the second information criterion using Hallin & Liska method

K1BN	estimated number of factors based on the first infomation criterion using Bai & Ng method
K2BN	estimated number of factors based on the second information criterion using Bai & Ng method

Author(s)

Jianqing Fan, Yuan Liao, Martina Mincheva

References

Bai,Ng,2002.Determining the number of factors in approximate factor models. Econometrica 70,191-221.

Hallin,Liska,2007.Determining the number of factors in the general dynamic factor model.JASA 102,603-617.

Alessi,Barigozzi,Capasso,2010. Improved penalization for determining the number of factors in approximate factor models. Statistics and Probability Letters 80, 1806-1813.

Examples

```
p=100
n=100
Y<-array(rnorm(p*n),dim=c(p,n))
K<-POETKhat(Y)
```

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