

Package ‘REFA’

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Type Package

Title Robust Exponential Factor Analysis

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Author Jiaqi Hu [cre, aut],
Xueqin Wang [aut]

Maintainer Jiaqi Hu <hujiaqi@mail.ustc.edu.cn>

Description A robust alternative to the traditional principal component estimator is proposed within the framework of factor models, known as Robust Exponential Factor Analysis, specifically designed for the modeling of high-dimensional datasets with heavy-tailed distributions. The algorithm estimates the latent factors and the loading by minimizing the exponential squared loss function. To determine the appropriate number of factors, we propose a modified rank minimization technique, which has been shown to significantly enhance finite-sample performance. For more detail of Robust Exponential Factor Analysis, please refer to Hu et al. (2026) <[doi:10.1016/j.jmva.2025.105567](https://doi.org/10.1016/j.jmva.2025.105567)>.

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ECC	<i>Estimation of errors for common component</i>
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Description

Estimation of errors for common component

Usage

ECC(Chat, C0)

Arguments

- Chat
- The estimated common component.
- C0
- The true common component.

Value

A numeric value of the ECC.

Author(s)

Jiaqi Hu

References

Robust factor analysis with exponential squared loss. Jiaqi Hu, Tingyin Wang, Xueqin Wang. Journal of Multivariate Analysis 2026, 213 105567; doi:10.1016/j.jmva.2025.105567

Examples

```
dat = gendata()
Y = dat$Y
F0 = dat$F0
L0 = dat$L0
C0 = F0 %**% t(L0)
res = REFA(dat$Y, r = 3)
Fhat = res$Fhat
Lhat = res$Lhat
Chat = Fhat %**% t(Lhat)
ECC(Chat, C0)
```

est_num

*Estimating Factor Numbers Corresponding PCA***Description**

Estimating Factor Numbers Corresponding PCA

Usage

```
est_num(X, kmax = 8, type = "BIC3")
```

Arguments

X	Input matrix, of dimension $T \times N$. Each row is an observation with N features at time point t .
kmax	The user-supplied maximum factor numbers.
type	The method used. Options include "PC1", "PC2", "PC3", "IC1", "IC2", "IC3", "AIC3", "BIC3", "ER", "GR".

Value

The estimated factor numbers.

Author(s)

Jiaqi Hu

Examples

```
dat = gendata()
est_num(dat$Y, kmax = 8, type = "BIC3")
```

FA

*Principal Component Analysis for Factor Models***Description**

Principal Component Analysis for Factor Models

Usage

```
FA(X, r)
```

Arguments

<code>X</code>	Input matrix, of dimension $T \times N$. Each row is an observation with N features at time point t .
<code>r</code>	A positive integer indicating the factor numbers.

Value

A list containing:

<code>Fhat</code>	The estimated factor matrix.
<code>Lhat</code>	The estimated loading matrix.

Author(s)

Jiaqi Hu

Examples

```
dat = gendata()
FA(dat$Y, r = 3)
```

<code>gendata</code>	<i>Data generation process</i>
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Description

Generate heavy-tailed data.

Usage

```
gendata(seed = 1, T = 50, N = 50, type = "1a")
```

Arguments

<code>seed</code>	The seed used in the data generation process.
<code>T</code>	Time dimension.
<code>N</code>	Cross-sectional dimension.
<code>type</code>	The type of the data generation process. Options include "1a", "1b", "1c", "1d", "2a", "2b", "2c", "2d", "3a", "3b".

Value

A list containing:

<code>Y</code>	The observed matrix.
<code>F0</code>	The true factor matrix.
<code>L0</code>	The true loading matrix.

Author(s)

Jiaqi Hu

References

Robust factor analysis with exponential squared loss. Jiaqi Hu, Tingyin Wang, Xueqin Wang. Journal of Multivariate Analysis 2026, 213 105567; doi:10.1016/j.jmva.2025.105567

Examples

```
dat = gendata()
Y = dat$Y
head(Y)
```

 REFA

Robust Exponential Factor Analysis

Description

Robust Exponential Factor Analysis

Usage

```
REFA(Y, r = 3, tau = 0.75, q = 0.05, eps = 1e-05, init = TRUE)
```

Arguments

Y	Input matrix, of dimension $T \times N$. Each row is an observation with N features at time point t .
r	A positive integer indicating the factor numbers.
tau	Hyper parameter in selecting γ of the loss function.
q	Hyper parameter used in the initializations, truncated PCA.
eps	The stopping criterion parameter. The default is 1e-5.
init	Warm start of the algorithm. If <code>init = TRUE</code> , use truncated PCA initialization. If <code>init</code> is a list contains <code>F0</code> and <code>L0</code> , we will use this initialization. Otherwise, use traditional PCA initialization.

Value

A list containing:

Fhat	The estimated factor matrix.
Lhat	The estimated loading matrix.
loss	The value of the loss function.

Author(s)

Jiaqi Hu

References

Robust factor analysis with exponential squared loss. Jiaqi Hu, Tingyin Wang, Xueqin Wang. Journal of Multivariate Analysis 2026, 213 105567; doi:10.1016/j.jmva.2025.105567

Examples

```
# Assuming gendata() is defined in your package
dat = gendata()
REFA(dat$Y, r = 3)
```

REFA_FN

*Estimating Factor Numbers via Modified Rank Minimization***Description**

Estimating Factor Numbers via Modified Rank Minimization

Usage

```
REFA_FN(Y, rmax = 8, tau = 0.75, q = 0.1, eps = 1e-04, init = TRUE)
```

Arguments

Y	Input matrix, of dimension $T \times N$. Each row is an observation with N features at time point t .
rmax	The bound of the number of factors.
tau	Hyper parameter in selecting γ of the loss function.
q	Hyper parameter used in the initializations, truncated PCA. Default is 0.05.
eps	The stopping criterion parameter. Default is 1e-5.
init	Warm start by truncated PCA algorithm. Default is TRUE.

Value

A list containing:

rhat	The estimated factor number.
Fhat	The estimated factor matrix.
Lhat	The estimated loading matrix.
loss	The value of the loss function.

Author(s)

Jiaqi Hu

References

Robust factor analysis with exponential squared loss. Jiaqi Hu, Tingyin Wang, Xueqin Wang. Journal of Multivariate Analysis 2026, 213 105567; doi:10.1016/j.jmva.2025.105567

Examples

```
# Assuming gendata() is defined in your package
dat = gendata()
REFA_FN(dat$Y, rmax = 8)
```

TR	<i>Trace ratios</i>
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Description

Trace ratios

Usage

```
TR(Fhat, F0)
```

Arguments

- Fhat The estimated factors.
- F0 The true factors.

Value

A numeric value of the trace ratios.

Author(s)

Jiaqi Hu

References

Robust factor analysis with exponential squared loss. Jiaqi Hu, Tingyin Wang, Xueqin Wang. Journal of Multivariate Analysis 2026, 213 105567; doi:10.1016/j.jmva.2025.105567

Examples

```
dat = gendata()
Y = dat$Y
F0 = dat$F0
res = REFA(dat$Y, r = 3)
Fhat = res$Fhat
TR(Fhat, F0)
```


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