Package 'REMLA'

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Title Robust Expectation-Maximization Estimation for Latent Variable Models

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Description Traditional latent variable models assume that the population is homogeneous, meaning that all individuals in the population are assumed to have the same latent structure. However, this assumption is often violated in practice given that individuals may differ in their age, gender, socioeconomic status, and other factors that can affect their latent structure. The robust expectation maximization (REM) algorithm is a statistical method for estimating the parameters of a latent variable model in the presence of population heterogeneity as recommended by Nieser & Cochran (2023) <doi:10.1037/met0000413>. The REM algorithm is based on the expectation-maximization (EM) algorithm, but it allows for the case when all the data are generated by the assumed data generating model.

License GPL (>= 3)

URL https://github.com/knieser/REM

Depends R (>= 4.0), GPArotation,geex

Imports stats

Encoding UTF-8

RoxygenNote 7.3.2

Suggests knitr, lavaan, rmarkdown, testthat (>= 3.0.0)

Config/testthat/edition 3

VignetteBuilder knitr

NeedsCompilation no

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Contents

controlREM *Control parameters for REM package*

Description

Control parameters for REM package

Usage

```
controlREM(
  steps = 25,
  tol = 1e-06,
  maxiter = 1000,
  min_weights = 1e-30,
  max_ueps = 0.3,
  chk_gamma = 0.9,
  n = 20000
)
```

Arguments

steps	number of steps in binary search for optimal epsilon value (default = 25)
tol	tolerance parameter to check for convergence of EM and REM algorithm (default = 1e-6)
maxiter	maximum number iterations of EM and REM algorithm (default = 1e3)
min_weights	lower bound for the individual weights estimated by REM (default = 1e-30)
max_ueps	percentile of the distribution of likelihood values to use as the maximum epsilon value to consider
chk_gamma	gamma value used when searching for epsilon
n	sample size of simulated data used when checking heuristic criterion in the epsilon search

Value

control parameters used in the REM package (steps, tol, maxiter, min_weights, ueps, n).

Author(s)

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References

Nieser, K. J., & Cochran, A. L. (2023). Addressing heterogeneous populations in latent variable settings through robust estimation. Psychological methods, 28(1), 39.

See Also

`REM_EFA()`, `REM_CFA()`

`REM_CFA` *Robust Estimation Maximization Estimates for Confirmatory Factor Analysis*

Description

This function uses the robust expectation maximization (REM) algorithm to estimate the parameters of a confirmatory factor analysis model as suggested by Nieser & Cochran (2023).

Usage

```
REM_CFA(X, delta = 0.05, model = NA, ctrREM = controlREM())
```

Arguments

`X`	data to analyze; should be a data frame or matrix
`delta`	hyperparameter between 0 and 1 that captures the researcher's tolerance of incorrectly down-weighting data from the model (default = 0.05).
`model`	string variable that contains each structural equation in a new line where equalities are denoted by the symbol "~".
`ctrREM`	control parameters (default: (steps = 25, tol = 1e-6, maxiter = 1e3, min_weights = 1e-30, max_ueps = 0.3, chk_gamma = 0.9, n = 2e4))

Value

REM_CFA returns an object of class "REM". The function `summary()` is used to obtain estimated parameters from the model. An object of class "REM" in Confirmatory Factor Analysis is a list of outputs with four different components: the matched call (call), estimates using traditional expectation maximization (EM_output), estimates using robust expectation maximization (REM_output), and a summary table (summary_table). The list contains the following components:

`call`	match call
`model`	model frame
`delta`	hyperparameter between 0 and 1 that captures the researcher's tolerance of incorrectly down-weighting data from the model
`k`	number of factors

`constraints` p x k matrix of zeros and ones denoting the factors (rows) and observed variables (columns)

`epsilon` hyperparameter on the likelihood scale

`AIC_rem` Akaike Information Criterion

`BIC_rem` Bayesian Information Criterion

`mu` item intercepts

`lambda` factor loadings

`psi` unique variances of items

`gamma` average weights

`weights` estimated REM weights

`ind_lik` likelihood value for each individual

`lik_rem` joint log-likelihood evaluated at REM estimates

`lik` joint log-likelihood evaluated at EM estimates

`summary_table` summary of EM and REM estimates, SEs, Z statistics, p-values, and 95% confidence intervals

Author(s)

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References

Nieser, K. J., & Cochran, A. L. (2023). Addressing heterogeneous populations in latent variable settings through robust estimation. Psychological methods, 28(1), 39.

See Also

`REM_EFA()`, `summary.REMLA()`

Examples

```
# CFA of Holzinger-Swineford dataset
library(lavaan)
df <- HolzingerSwineford1939
data = df[,-c(1:6)]

model <- "Visual  =~  x1 + x2 + x3
          Textual =~  x4 + x5 + x6
          Speed   =~  x7 + x8 + x9"

model_CFA = REM_CFA(X = data, model = model)
summary(model_CFA)
```

REM_EFA *Robust Estimation Maximization for Exploratory Factor Analysis*

Description

This function uses the robust expectation maximization (REM) algorithm to estimate the parameters of an exploratory factor analysis model as suggested by Nieser & Cochran (2023).

Usage

```
REM_EFA(X, k_range, delta = 0.05, rotation = "oblimin", ctrREM = controlREM())
```

Arguments

`X`	data to analyze; should be a data frame or matrix
`k_range`	vector of the number of factors to consider
`delta`	hyperparameter between 0 and 1 that captures the researcher's tolerance of incorrectly down-weighting data from the model (default = 0.05)
`rotation`	factor rotation method (default = 'oblimin'); 'varimax' is the only other available option at this time
`ctrREM`	control parameters (default: (steps = 25, tol = 1e-6, maxiter = 1e3, min_weights = 1e-30, max_ueps = 0.3, chk_gamma = 0.9, n = 2e4))

Value

REM_EFA returns an object of class "REM". The function `summary()` is used to obtain estimated parameters from the model. An object of class "REM" in Exploratory Factor Analysis is a list of outputs with four different components for each number of factor: the matched call (call), estimates using traditional expectation maximization (EM_output), estimates using robust expectation maximization (REM_output), and a summary table (summary_table). The list contains the following components:

`call`	match call
`model`	model frame
`k`	number of factors
`constraints`	p x k matrix of zeros and ones denoting the factors (rows) and observed variables (columns)
`epsilon`	hyperparameter on the likelihood scale
`AIC_rem`	Akaike information criterion based on REM estimates
`BIC_rem`	Bayesian information criterion based on REM estimates
`mu`	item intercepts
`lambda`	factor loadings
`psi`	unique variances of items

`phi`	factor covariance matrix
`gamma`	average weight
`weights`	estimated REM weights
`ind_lik`	likelihood value for each individual
`lik_rem`	joint log-likelihood evaluated at REM estimates
`lik`	joint log-likelihood evaluated at EM estimates
`mu.se`	standard errors of items intercepts
`lambda.se`	standard errors of factor loadings
`psi.se`	standard errors of unique variances of items
`gamma.se`	standard error of gamma
`summary_table`	summary of EM and REM estimates, SEs, Z statistics, p-values, and 95% confidence intervals

The summary function can be used to obtain estimated parameters from the optimal model based on the BIC from the EM and REM algorithms.

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References

Nieser, K. J., & Cochran, A. L. (2023). Addressing heterogeneous populations in latent variable settings through robust estimation. Psychological methods, 28(1), 39.

See Also

`REM_CFA()`, `summary.REMLA()` for more detailed summaries, `GPArotation::oblimin()` and `varimax()` for details on the rotation

Examples

```
# EFA of Holzinger-Swineford dataset
library(lavaan)
df <- HolzingerSwineford1939
data = df[,-c(1:6)]

model_EFA = REM_EFA(X = data, k_range = 1:3)
summary(model_EFA)
```

`summary.REMLA` *Summary for Robust Estimation Maximization*

Description

Summary method for class "REMLA".

Usage

```
## S3 method for class 'REMLA'
summary(object, ...)
```

Arguments

`object`	an object of class "REMLA", usually a result of a call to REM_EFA.
`...`	further arguments passed to or from other methods.

Value

The summary.REM function returns estimated parameters from the optimal model based on the BIC from the EM and REM algorithms.

Output include:

`optimal`	optimal number of factors based on BIC
`mu`	intercept
`lambda`	loadings
`psi`	variance
`indk_lik`	likelihood value for each individual
`epsilon`	hyperparameter on the likelihood scale
`diff`	differences between EM and REM

Author(s)

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References

Nieser, K. J., & Cochran, A. L. (2023). Addressing heterogeneous populations in latent variable settings through robust estimation. Psychological methods, 28(1), 39.

See Also

`REM_EFA()`, `REM_CFA()`, `summary()`.

Index