

Package ‘EFA.MRFA’

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Type Package

Title Dimensionality Assessment Using Minimum Rank Factor Analysis

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Description Performs parallel analysis (Timmerman & Lorenzo-Seva, 2011 <doi:10.1037/a0023353>) and hull method (Lorenzo-Seva, Timmerman, & Kiers, 2011 <doi:10.1080/00273171.2011.564527>) for assessing the dimensionality of a set of variables using minimum rank factor analysis (see ten Berge & Kiers, 1991 <doi:10.1007/BF02294464> for more information). The package also includes the option to compute minimum rank factor analysis by itself, as well as the greater lower bound calculation.

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EFA.MRFA-package	<i>Dimensionality Assesment using Minimum Rank Factor Analysis (MRFA)</i>
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Description

Package for performing Parallel Analysis using Minimum Rank Factor Analysis (MRFA) . It also include a function to perform the MRFA only and another function to compute the Greater Lower Bound step for estimating the variables communalities.

Details

For more information about the methods used in each function, please go to each main page.

Value

paralle1MRFA	Performs Parallel Analysis using Minimum Rank Factor Analysis (MRFA).
hulleFA	Performs Hull analysis for assessing the number of factors to retain.
mrfa	Performs Minimum Rank Factor Analysis (MRFA) procedure.
GreaterLowerBound	Estimates the communalities of the variables from a factor model.
testme	An auto-executable script for testing the functions included in DA.MRFA.

Author(s)

David Navarro-Gonzalez
Urbano Lorenzo-Seva

References

- Devlin, S. J., Gnanadesikan, R., & Kettenring, J. R. (1981). Robust estimation of dispersion matrices and principal components. *Journal of the American Statistical Association*, 76, 354-362. <http://doi.org/10.1080/01621459.1981.10477654>
- Lorenzo-Seva, U., Timmerman, M. E., & Kiers, H. A. (2011). The Hull Method for Selecting the Number of Common Factors. *Multivariate Behavioral Research*, 46(2), 340-364. <https://doi.org/10.1080/00273171.2011.564527>
- ten Berge, J. M. F., & Kiers, H. A. L. (1991). A numerical approach to the approximate and the exact minimum rank of a covariance matrix. *Psychometrika*, 56(2), 309-315. <http://doi.org/10.1007/BF02294464>
- Ten Berge, J.M.F., Snijders, T.A.B. & Zegers, F.E. (1981). Computational aspects of the greatest lower bound to reliability and constrained minimum trace factor analysis. *Psychometrika*, 46, 201-213.
- Timmerman, M. E., & Lorenzo-Seva, U. (2011). Dimensionality assessment of ordered polytomous items with parallel analysis. *Psychological Methods*, 16(2), 209-220. <http://doi.org/10.1037/a0023353>

Examples

```
## Each man page contains examples of each function. For a fast global example use
testme(example = TRUE)

## For speeding purposes, the number of datasets have been largely reduced. For a proper
## use of testme, use it without the "example" argument or using example=FALSE.
```

GreaterLowerBound *Greater Lower Bound step (glb)*

Description

Estimates the communalities of the variables from a factor model where the number of factors is the number with positive eigenvalues.

Usage

```
GreaterLowerBound(C, conv = 0.000001, T, pwarnings = FALSE)
```

Arguments

C	Covariance/correlation matrix to be used in the analysis.
conv	Convergence criterion for glb step. The default convergence criterion will be conv=0.000001 . If the user determine a specific value, this will prevail.
T	Random matrix for start (can be omitted). If provided, it has to be the same size than the matrix provided in the C argument.
pwarnings	Determines if the possible warnings occurred during the computation will be printed in the console.

Details

Code adapted from a MATLAB function by Jos Ten Berge based on Ten Berge, Snijders & Zegers (1981) and Ten Berge & Kiers (1991).

Value

gam	Optimal communalities for each variable
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Author(s)

David Navarro-Gonzalez
Urbano Lorenzo-Seva

References

Ten Berge, J.M.F., & Kiers, H.A.L. (1991). A numerical approach to the exact and the approximate minimum rank of a covariance matrix. *Psychometrika*, 56, 309-315.

Ten Berge, J.M.F., Snijders, T.A.B. & Zegers, F.E. (1981). Computational aspects of the greatest lower bound to reliability and constrained minimum trace factor analysis. *Psychometrika*, 46, 201-213.

Examples

```
## perform glb using the correlation matrix of the IDAQ dataset, and using severe convergence
## criterion.
GreaterLowerBound(cor(IDAQ), conv=0.000001)
```

hulleFA

Hull method for selecting the number of common factors

Description

Performs the Hull method (Lorenzo-Seva, Timmerman, & Kiers, 2011), which aims to find a model with an optimal balance between model fit and number of parameters.

Usage

```
hulleFA(X, maxQ, extr = "ULS", index_hull = "CAF", display = TRUE, graph = TRUE,
        details = TRUE)
```

Arguments

X	Raw sample scores.
maxQ	Maximum of dimensions to be tested. By default it will be determined by the Parallel Analysis advised dimensions, but the user can define it manually.
extr	Extraction method, the two options available being: "ULS" (Unweighed Least Squares, by default) and "ML" (Maximum Likelihood).
index_hull	The index that will be used for determining the number of dimensions. The available options are the following: "CAF", "CFI""RMSEA", being "CAF" by default.
display	Determines if the output will be displayed in the console, TRUE by default. If it is TRUE, the output is returned silently and if it is FALSE, the output is returned in the console.
graph	Request a plot representing the Hull curve.
details	If detailed table will be displayed, containing the factors outside the convex Hull.

Details

hullEFA is based on the procedure proposed by Lorenzo-Seva, Timmerman, & Kiers (2011) which is designed for assessing the dimensionality of a variable set. The hull heuristic was originally proposed by Ceulemans & Kiers (2006) in the context of model selection in multiway data analysis.

The hull analysis is performed in four main steps:

1. The range of factors to be considered is determined.
2. The goodness-of-fit of a series of factor solutions is assessed.
3. The degrees of freedom of the series of factor solutions is computed.
4. The elbow is located in the higher boundary of the convex hull of the hull plot.

The number of factors extracted in the solution associated with the elbow is considered the optimal number of common factors.

In the Lorenzo-Seva, Timmerman, & Kiers (2011) simulation study, the Hull method outperformed the other selected methods in recovering the correct number of major factors.

Value

Matrix	Matrix containing the results of the Hull method using for the selected index.
n_factors	Number of advised dimensions by the selected index.

Author(s)

David Navarro-Gonzalez

Urbano Lorenzo-Seva

References

Lorenzo-Seva, U., Timmerman, M. E., & Kiers, H. A. (2011). The Hull Method for Selecting the Number of Common Factors. *Multivariate Behavioral Research*, 46(2), 340-364. <https://doi.org/10.1080/00273171.2011.564527>

Ceulemans, E., & Kiers, H. A. L. (2006). Selecting among three-mode principal component models of different types and complexities: A numerical convex hull based method. *British Journal of Mathematical and Statistical Psychology*, 59: 133–150. <https://doi.org/10.1348/000711005X64817>

Examples

```
## Perform the Hull method defining the maximum number of dimensions to be tested by the
## Parallel Analysis + 1 rule, with Maximum Likelihood factor extraction method and CAF
## as Hull index.
hullEFA(IDAQ, extr = "ML")
```

IDAQ

IDAQ database

Description

A database to be used as example in the functions included on DA.MRFA package. It contains the answers of 100 participants to IDAQ questionnaire (Ruiz-Pamies, Lorenzo-Seva, Morales-Vives, Cosi, Vigil-Colet, 2014), which was developed for assessing Physical, Verbal and Indirect aggression. The original questionnaire contains 27 Likert-items, ranging from 1 to 5.

Usage

```
data("IDAQ")
```

Format

A data frame with 100 observations and 23 variables measuring 3 different types of aggression (Physical, Verbal and Indirect).

Details

The original sample contains 27 items, because includes 4 Social Desirability markers, but for the purpose of the DA.MRFA functions, they had been removed. Also, the original sample contains 750 participants, and the following database only contains 100 for speeding purposes.

Source

More information about the questionnaire can be found at:

<http://psico.fcep.urv.cat/tests/idaq/en/descripcion.html>

References

Ruiz-Pamies, M., Lorenzo-Seva, U., Morales-Vives, F., Cosi, S., & Vigil-Colet, A. (2014). I-DAQ: a new test to assess direct and indirect aggression free of response bias. *The Spanish Journal of Psychology*, 17, E41. <http://doi.org/10.1017/sjp.2014.43>

Examples

```
data(IDAQ)
```

mrfa *Minimum Rank Factor Analysis function*

Description

Performs Minimum Rank Factor Analysis (MRFA) procedure, proposed by Ten Berge & Kiers (1991).

Usage

```
mrfa(SIGMA, dimensionality = 1, random = 10, conv1, conv2, display = TRUE,
      pwarnings = FALSE)
```

Arguments

SIGMA	Covariance/correlation matrix to be used in the analysis.
dimensionality	Common factors used to find communality estimates. The value has to be between 0 and the number of items minus 1, being the default option: 1 dimension to be retained. If 0 is selected, a more strict convergence criterion will be used.
random	Number of random starts.
conv1	Convergence criterion for MRFA. The default convergence criterion will be conv1=0.0001 . If the user determine a specific value, this will prevail.
conv2	Convergence criterion for glb step. The default convergence criterion will be conv2=0.001 . If the user determine a specific value, this will prevail.
display	Determines if the output will be displayed in the console, TRUE by default. If it is TRUE, the output is returned silently and if it is FALSE, the output is returned in the console.
pwarnings	Determines if the possible warnings occurred during the computation will be printed in the console.

Value

A	Factor loading matrix
Matrix	Covariance/Correlation matrix with optimal communalities in the diagonal
gam	Optimal communalities for each variable

Author(s)

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References

ten Berge, J. M. F., & Kiers, H. A. L. (1991). A numerical approach to the approximate and the exact minimum rank of a covariance matrix. *Psychometrika*, 56(2), 309-315. <http://doi.org/10.1007/BF02294464>

Examples

```
## perform MRFA using the correlation matrix of the IDAQ dataset, and using the default
## convergence criterion for MRFA and glb step.
mrfa(cor(IDAQ), dimensionality=3)
```

parallelMRFA

Parallel Analysis using Minimum Rank Factor Analysis (MRFA)

Description

Performs Parallel Analysis using Minimum Rank Factor Analysis (MRFA).

Usage

```
parallelMRFA(X, Ndatsets = 500, percent = 95, corr= "Pearson", display = TRUE,
graph = TRUE)
```

Arguments

X	Raw sample scores.
Ndatsets	Number of random datasets used to compute the random distribution of eigenvalues.
percent	Desired percentile of distribution of random eigenvalues (for example 95 for the 95th percentile) to be used as threshold.
corr	Determine if Pearson or Polychoric matrix will be used "Pearson": Computes Pearson correlation matrix "Polychoric": Computes Polychoric/Tetrachoric correlation matrix (heavy time consuming).
display	Determines if the output will be displayed in the console, TRUE by default. If it is TRUE, the output is returned silently and if it is FALSE, the output is returned in the console.
graph	Request a plot representing the percentage of explained variance by the real data, by the mean of the random data and using the percentile of distribution of random eigenvalues, defined in the percent argument.

Details

parallelMRFA is based on the procedure proposed by Timmerman and Lorenzo-Seva (2011) which is designed for assessing the dimensionality of a variable set. The principal advantage of using MRFA (Ten Berge & Kiers, 1991) instead the usual PCA extraction process is that the eigenvalues obtained from MRFA can be used to estimate the explained common variance per factor.

The eigenvalue sampling distribution is obtaining using a nonparametric approach: a permutation of the raw data (Buja & Eyuboglu, 1992). This approach is recommended for PA especially in cases where the observed data ditribution clearly deviates from normality.

If the matrix to analyze is not positive-defined, a smoothening procedure will be applied (Devlin, Gnanadesikan & Kettenring, 1981).

Value

Real_Data	A vector containing the percentage of explained variance by the real data for each factor
Mean_random	A vector containing the percentage of explained variance by the mean of random data for each factor
Percentile_random	A vector containing the percentage of explained variance by the percentile of distribution of random data for each factor
Number_factors_mean	The number of factors to be retained suggested comparing the real data with the mean of the random data
Number_factors_percentiles	The number of factors to be retained suggested comparing the real data with the percentile of distribution of the random data

Author(s)

David Navarro-Gonzalez

Urbano Lorenzo-Seva

References

Buja, A., & Eyuboglu, N. (1992). Remarks on Parallel Analysis. *Multivariate Behavioral Research*, 27(4), 509-540. http://doi.org/10.1207/s15327906mbr2704_2

Devlin, S. J., Gnanadesikan, R., & Kettenring, J. R. (1981). Robust estimation of dispersion matrices and principal components. *Journal of the American Statistical Association*, 76, 354-362. <http://doi.org/10.1080/01621459.1981.10477654>

ten Berge, J. M. F., & Kiers, H. A. L. (1991). A numerical approach to the approximate and the exact minimum rank of a covariance matrix. *Psychometrika*, 56(2), 309-315. <http://doi.org/10.1007/BF02294464>

Timmerman, M. E., & Lorenzo-Seva, U. (2011). Dimensionality assessment of ordered polytomous items with parallel analysis. *Psychological Methods*, 16(2), 209-220. <http://doi.org/10.1037/a0023353>

Examples

```
## perform a Parallel Analysis using an example Database with only 10 random data sets and
## using the 90th percentile of distribution of the random data
parallelMRFA(IDAQ, Ndatsets=10, percent=90)
```

```
## For speeding purposes, the number of datasets have been largely reduced. For a proper
## use of parallelMRFA, we recommend to use the default Ndatsets value (Ndatsets=500)
```

testme

Function for test the full capabilities of EFA.MRFA package

Description

testme is a function which includes all the functions available in the EFA.MRFA package, and his purpose is to serve as a demonstration of the potential usage of the package functions.

Usage

```
testme(example = FALSE)
```

Arguments

example Determine if the usage is for exempling purpose or not (FALSE by default).

Details

The function implements all the functions on the EFA.MRFA package. For ilustrating purposes, the loading matrix obtained using MRFA (`mrfa` function) is rotated using the function `promin` (Lorenzo-Seva, 1999), from PCovR package (Vervloet, Kiers, Van den Noortgate & Ceulemans, 2015).

Both procedures for assessing the number of factors to be retained are provided. As can be seen, the procedures differ on the number of factors suggested, with Parallel Analysis suggesting 3 factors (corresponding to the 3 sub-dimensions of aggression), while Hull only suggests one factor to be retained, corresponding to the general agression factor.

Author(s)

David Navarro-Gonzalez

Urbano Lorenzo-Seva

References

Lorenzo-Seva, U. (1999). Promin: A Method for Oblique Factor Rotation. *Multivariate Behavioral Research*, 34(3), 347–365 http://doi.org/10.1207/S15327906MBR3403_3

Vervloet, M., Kiers, H. A. L., Van den Noortgate, W., & Ceulemans, E. (2015). PCovR: An R Package for Principal Covariates Regression. *JSS Journal of Statistical Software*, 65(8). <http://doi.org/10.18637/jss.v065.i08>

Examples

```
## For a fast usage of testme use:  
testme(example=TRUE)
```

```
## For speeding purposes, the number of datasets have been largely reduced. For a proper  
## use of testme, use testme() or using testme(example=FALSE).
```

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