Package 'mulSEM'

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Description A set of functions for some multivariate analyses utilizing a structural equation modeling (SEM) approach through the 'OpenMx' package. These analyses include canonical correlation analysis (CANCORR), redundancy analysis (RDA), and multivariate principal component regression (MPCR). It implements procedures discussed in Gu and Cheung (2023) <doi:10.1111/bmsp.12301>, Gu, Yung, and Cheung (2019) <doi:10.1080/00273171.2018.1512847>, and Gu et al. (2023) <doi:10.1080/00273171.2022.2141675>.

License GPL (>= 2)

LazyLoad yes

LazyData yes

ByteCompile yes

URL https://github.com/mikewlcheung/mulsem

BugReports https://github.com/mikewlcheung/mulsem/issues

NeedsCompilation no

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`mulSEM-package` *Some Multivariate Analyses using Structural Equation Modeling*

Description

A set of functions for some multivariate analyses utilizing a structural equation modeling (SEM) approach through the 'OpenMx' package. These analyses include canonical correlation analysis (CANCORR), redundancy analysis (RDA), and multivariate principal component regression (MPCR). It implements procedures discussed in Gu and Cheung (2023) <doi:10.1111/bmsp.12301>, Gu, Yung, and Cheung (2019) <doi:10.1080/00273171.2018.1512847>, and Gu et al. (2023) <doi:10.1080/00273171.2022.2

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References

Gu, F., & Cheung, M. W.-L. (2023). A Model-based approach to multivariate principal component regression: Selection of principal components and standard error estimates for unstandardized regression coefficients. *British Journal of Mathematical and Statistical Psychology*, **76(3)**, 605-622. https://doi.org/10.1111/bmsp.12301

Gu, F., Yung, Y.-F., & Cheung, M. W.-L. (2019). Four covariance structure models for canonical correlation analysis: A COSAN modeling approach. *Multivariate Behavioral Research*, **54**(2), 192-223. https://doi.org/10.1080/00273171.2018.1512847

Gu, F., Yung, Y.-F., Cheung, M. W.-L. Joo, B.-K., & Nimon, K. (2022). Statistical inference in redundancy analysis: A direct covariance structure modeling approach. *Multivariate Behavioral Research*, **58(5)**, 877-893. https://doi.org/10.1080/00273171.2022.2141675

Examples

```
## Canonical Correlation Analysis
cancorr(X_vars=c("Weight", "Waist", "Pulse"),
        Y_vars=c("Chins", "Situps", "Jumps"),
        data=sas_ex1)

## Redundancy Analysis
rda(X_vars=c("x1", "x2", "x3", "x4"),
    Y_vars=c("y1", "y2", "y3"),
    data=sas_ex2)

## Multivariate Principal Component Regression
mpcr(X_vars=c("AU", "CC", "CL", "CO", "DF", "FB", "GR", "MW"),
     Y_vars=c("IDE", "IEE", "IOCB", "IPR", "ITS"),
     pca="COR", pc_select=1,
     data=Nimon21)
```

`cancorr` *Canonical Correlation Analysis*

Description

It conducts a canonical correlation analysis using the OpenMx package. Missing data are handled with the full information maximum likelihood method when raw data are available. It provides standard errors on the estimates.

Usage

```
cancorr(X_vars, Y_vars, data=NULL, Cov, numObs,
        model=c("CORR-W", "CORR-L", "COV-W", "COV-L"),
        extraTries=50, ...)
```

Arguments

`X_vars`	A vector of characters of the X variables.
`Y_vars`	A vector of characters of the Y variables.
`data`	A data frame of raw data.
`Cov`	A covariance or correlation matrix if `data` is not available.
`numObs`	A sample size if `data` is not available.
`model`	Four models defined in Gu, Yung, and Cheung (2019). `CORR` and `COV` refer to the analysis of correlation structure and covariance structure, respectively.
`extraTries`	This function calls `mxTryHard` to obtain the parameter estimates and their standard errors. `extraTries` indicates the number of extra runs. If `extraTries=0`, `mxRun` is called.
`...`	Additional arguments sent to either `mxTryHard` or `mxRun`.

Value

A list of output with class `CanCor`. It stores the model in OpenMx objects. The fitted object is in the slot of `mx.fit`.

Note

`cancorr` expects that there are equal or more number of variables in `Y_vars`. If there are fewer variables in `Y_vars`, you may swap between `X_vars` and `Y_vars`.

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References

Gu, F., Yung, Y.-F., & Cheung, M. W.-L. (2019). Four covariance structure models for canonical correlation analysis: A COSAN modeling approach. *Multivariate Behavioral Research*, **54(2)**, 192-223. https://doi.org/10.1080/00273171.2018.1512847

See Also

`Thorndike00`, `sas_ex1`

Chittum19 *Correlation matrix of a model of motivation*

Description

This dataset includes a correlation matrix of 12 variables (n=533) of a model of motivation reported by Chittum, Jones, and Carter (2019).

Usage

```
data("Chittum19")
```

Details

A list of data with the following structure:

data A 12x12 correlation matrix.

n A sample size.

Source

Chittum, J. R., Jones, B. D., & Carter, D. M. (2019). A person-centered investigation of patterns in college students' perceptions of motivation in a course. *Learning and Individual Differences*, **69**, 94-107. https://doi.org/10.1016/j.lindif.2018.11.007

References

Gu, F., Yung, Y.-F., Cheung, M. W.-L. Joo, B.-K., & Nimon, K. (2023). Statistical inference in redundancy analysis: A direct covariance structure modeling approach. *Multivariate Behavioral Research*, **58(5)**, 877-893. https://doi.org/10.1080/00273171.2022.2141675

Examples

```
data(Chittum19)

## Redundancy Analysis
rda(X_vars=c("Empowerment", "Usefulness", "Success", "Interest", "Caring"),
    Y_vars=c("Final_Exam", "Learning", "Course_Rating", "Instr_Rating",
             "Effort", "Cog_Engage", "Cost"),
    Cov=Chittum19$data, numObs=Chittum19$n)
```

Lambert88 *Correlation matrix of artificial data*

Description

This dataset includes a correlation matrix of the artificial data 9 variables used in Table 1 of Lambert, Wildt, and Durand (1988).

Usage

```
data("Lambert88")
```

Details

A 9x9 correlation matrix.

Source

Lambert, Z. V., Wildt, A. R., & Durand, R. M. (1988). Redundancy analysis: An alternative to canonical correlation and multivariate multiple regression in exploring interset associations. *Psychological Bulletin*, **104**(2), 282-289. https://doi.org/10.1037/0033-2909.104.2.282

References

Gu, F., Yung, Y.-F., Cheung, M. W.-L. Joo, B.-K., & Nimon, K. (2023). Statistical inference in redundancy analysis: A direct covariance structure modeling approach. *Multivariate Behavioral Research*, **58(5)**,877-893. https://doi.org/10.1080/00273171.2022.2141675

Examples

```
data(Lambert88)

## Redundancy Analysis
rda(X_vars=paste0("x", 1:5), Y_vars=paste0("y", 1:4), Cov=Lambert88, numObs=100)
```

mpcr *Multivariate Principal Component Regression (MPCR)*

Description

It conducts a multivariate principal component regression analysis using the OpenMx package. Missing data are handled with the full information maximum likelihood method when raw data are available. It provides standard errors on the estimates.

Usage

```
mpcr(X_vars, Y_vars, data=NULL, Cov, Means=NULL, numObs, pca=c("COV", "COR"),
     pc_select=NULL, extraTries=50, ...)
```

Arguments

X_vars	A vector of characters of the X variables.
Y_vars	A vector of characters of the Y variables.
data	A data frame of raw data.
Cov	A covariance or correlation matrix if data is not available.
Means	An optional mean vector if data is not available.
numObs	A sample size if data is not available.
pca	Whether the principal component analysis is based unstandardized COV or standardized COR variables.
pc_select	PCs selected in the regression analysis. For example, pc_select=c(1,2) to use the first two PCs in the multiple regression analysis.
extraTries	This function calls mxTryHard to obtain the parameter estimates and their standard errors. extraTries indicates the number of extra runs. If extraTries=0, mxRun is called.
...	Additional arguments sent to either mxTryHard or mxRun.

Value

A list of output with class MPCR. It stores the model in OpenMx objects. The fitted object is in the slot of mx.fit.

Author(s)

Mike W.-L. Cheung <mikewlcheung@nus.edu.sg>

References

Gu, F., & Cheung, M. W.-L. (2023). A Model-based approach to multivariate principal component regression: Selection of principal components and standard error estimates for unstandardized regression coefficients. *British Journal of Mathematical and Statistical Psychology*, **76(3)**, 605-622. https://doi.org/10.1111/bmsp.12301

See Also

Nimon21

Nimon21 *Raw data used in Nimon, Joo, and Bontrager (2021)*

Description

This dataset includes the raw data of 13 variables reported by Nimon, Joo, and Bontrager (2021).

Usage

```
data("Nimon21")
```

Details

A data frame of 13 variables.

Source

Nimon, K., Joo, B.-K. (Brian), & Bontrager, M. (2021). Work cognitions and work intentions: A canonical correlation study. *Human Resource Development International*, **24**(1), 65-91. https://doi.org/10.1080/13678868.20

References

Gu, F., & Cheung, M. W.-L. (2023). A Model-based approach to multivariate principal component regression: Selection of principal components and standard error estimates for unstandardized regression coefficients. *British Journal of Mathematical and Statistical Psychology*, **76(3)**, 605-622. https://doi.org/10.1111/bmsp.12301 Gu, F., Yung, Y.-F., Cheung, M. W.-L. Joo, B.-K., & Nimon, K. (2023). Statistical inference in redundancy analysis: A direct covariance structure modeling approach. *Multivariate Behavioral Research*, **58(5)**, 877-893. https://doi.org/10.1080/00273171.2022.2141675

Examples

```
data(Nimon21)

## Redundancy Analysis
rda(X_vars=c("AU", "CC", "CL", "CO", "DF", "FB", "GR", "MW"),
    Y_vars=c("IDE", "IEE", "IOCB", "IPR", "ITS"),
    data=Nimon21)

## Multivariate Principal Component Regression
mpcr(X_vars=c("AU", "CC", "CL", "CO", "DF", "FB", "GR", "MW"),
     Y_vars=c("IDE", "IEE", "IOCB", "IPR", "ITS"),
     pca="COR", pc_select=1,
     data=Nimon21)
```

print *Print Methods for various Objects*

Description

Print method for CanCorr and RDA objects.

Usage

```
## S3 method for class 'CanCorr'
print(x, digits=4, ...)
## S3 method for class 'RDA'
print(x, digits=4, ...)
## S3 method for class 'MPCR'
print(x, digits=4, ...)
```

Arguments

x	An object returned from the class of either CanCorr, RDA, or MPCR.
digits	Number of digits in printing the matrices. The default is 4.
...	Unused.

Value

No return value, called for side effects

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rda *Redundancy Analysis*

Description

It conducts a redundancy analysis using the OpenMx package. Missing data are handled with the full information maximum likelihood method when raw data are available. It provides standard errors on the standardized estimates.

Usage

```
rda(X_vars, Y_vars, data=NULL, Cov, numObs, extraTries=50, ...)
```

Arguments

X_vars	A vector of characters of the X variables.
Y_vars	A vector of characters of the Y variables.
data	A data frame of raw data.
Cov	A covariance or correlation matrix if data is not available.
numObs	A sample size if data is not available.
extraTries	This function calls mxTryHard to obtain the parameter estimates and their standard errors. extraTries indicates the number of extra runs. If extraTries=0, mxRun is called.
...	Additional arguments sent to either mxTryHard or mxRun.

Value

A list of output with class RDA. It stores the model in OpenMx objects. The fitted object is in the slot of mx.fit.

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References

Gu, F., Yung, Y.-F., Cheung, M. W.-L. Joo, B.-K., & Nimon, K. (2023). Statistical inference in redundancy analysis: A direct covariance structure modeling approach. *Multivariate Behavioral Research*, **58(5**, 877-893. https://doi.org/10.1080/00273171.2022.2141675

See Also

Chittum19, sas_ex2

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sas_ex1 *Sample data for canonical correlation analysis from the SAS manual*

Description

This dataset includes six variables of fitness club data from the SAS manual.

Usage

```
data("sas_ex1")
```

Details

A 20x6 data matrix.

Source

https://documentation.sas.com/doc/en/statcdc/14.2/statug/statug_cancorr_example01.htm

Examples

```
data(sas_ex1)

## Canonical Correlation Analysis
cancorr(X_vars=c("Weight", "Waist", "Pulse"),
        Y_vars=c("Chins", "Situps", "Jumps"),
        data=sas_ex1)
```

---

sas_ex2 *Sample data for redundancy analysis from the SAS manual*

Description

This dataset includes seven variables from the SAS manual.

Usage

```
data("sas_ex2")
```

Details

A 10x7 data matrix.

Source

https://documentation.sas.com/doc/en/pgmsascdc/9.4_3.3/statug/statug_transreg_details23.htm

Examples

```
data(sas_ex2)

## Redundancy Analysis
rda(X_vars=c("x1", "x2", "x3", "x4"),
    Y_vars=c("y1", "y2", "y3"),
    data=sas_ex2)
```

Thorndike00 *Correlation matrix of a model of disgust*

Description

This dataset includes a correlation matrix of 13 variables (n=679) between five subscales (y1 to y5) of the Disguest Emotion Scale and eight subscales (x1 to x8) of the Disgust Scale reported by Thorndike (2000, p. 238).

Usage

```
data("Thorndike00")
```

Details

A list of data with the following structure:

data A 13x13 correlation matrix.

n A sample size.

Source

Thorndike, R. M. (2000). Canonical correlation analysis. In H. E. A. Tinsley & S. D. Brown (Eds.), *Handbook of applied multivariate statistics and mathematical modeling* (pp. 237-263). San Diego, CA: Academic Press.

References

Gu, F., Yung, Y.-F., & Cheung, M. W.-L. (2019). Four covariance structure models for canonical correlation analysis: A COSAN modeling approach. *Multivariate Behavioral Research*, **54(2)**, 192-223. https://doi.org/10.1080/00273171.2018.1512847

Examples

```
data(Thorndike00)

## Canonical Correlation Analysis
## Note. We swap the X_vars and Y_vars because cancorr() expects that
## X_vars cannot have more variables than Y_vars.

cancorr(X_vars=c("y1", "y2", "y3", "y4", "y5"),
        Y_vars=c("x1", "x2", "x3", "x4", "x5", "x6", "x7", "x8"),
        Cov=Thorndike00$data, numObs=Thorndike00$n)
```

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