Package 'mstDIF'

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Type Package

Title A Collection of DIF Tests for Multistage Tests

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Description A Collection of statistical tests for the detection of differential item functioning (DIF) in multistage tests. Methods entail logistic regression, an adaptation of the simultaneous item bias test (SIBTEST), and various score-based tests. The presented tests provide itemwise checks that item response curves remain stable with regard to categorical, ordinal or metric covariates. Methods for uniform and non-uniform DIF effects are available.

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R topics documented:

`mstDIF-package` *mstDIF: A Collection of Statistical Tests for DIF Detection in Multi-stage Tests*

Description

A Collection of Statistical Tests for the Detection of Differential Item Functioning (DIF) in Multi-stage Tests. Methods entail logistic regression, mstSIB, and various score-based tests.

`bootstrap_sctest` *A score-based DIF test using the parametric bootstrap approach.*

Description

`bootstrap_sctest` computes score test to detect DIF in multiple item/parameters with respect to multiple person covariates (`DIF_covariate`). To obtain the p-values a resampling approach is applied. That is, given the (item and person) parameters, new data sets are sampled to create the distribution of the test statistic under the null-hypothesis. The functionality is limited to the 1-, 2-, and 3-parameter logistic models. Only DIF with respect to the `a` and `b` parameters are tested for, respectively the item discriminations and the item difficulties.

Usage

```
bootstrap_sctest(
  resp,
  theta = NULL,
  a = rep(1, length(b)),
  b,
  c = rep(0, length(b)),
  DIF_covariate = NULL,
  parameters = c("per_item", "ab", "a", "b"),
  item_selection = NULL,
  nSamples = 1000,
  theta_method = c("wle", "mle", "eap", "map"),
  slope_intercept = FALSE,
  statistic = "auto",
  meanCenter = TRUE,
  decorrelate = FALSE,
  impact_groups = rep(1, dim(resp)[1])
)
```

Arguments

`resp`	A matrix (or data frame) containing the responses, with the items in the columns.
`theta`	A vector with the true/estimated ability parameters or NULL (the default) which leads to the ability parameters being estimated.
`a`	A vector of item slopes/item discriminations.
`b`	A vector of item locations/item difficulties.

c	A vector of pseudo guessing parameters.
DIF_covariate	A list with the person covariate(s) to test for as element(s).
parameters	A character string, either "per_item", "ab", "a", or "b", to specify which parameters should be tested for.
item_selection	A character vector with the column names or an integer vector with the column numbers in the resp, specifying the items for which the test should be computed. When set to NULL (i.t., the default), all the items are tested.
nSamples	An integer value with the number of permutations to be sampled.
theta_method	A character string, either "wle", "mle", "eap", of "map" that specifies the estimator for the ability estimation. Only relevant when theta == NULL.
slope_intercept	A logical value indicating whether the slope-intercept formulation of the 2-/3-PL model should be used.
statistic	A character string, either "auto", "DM", "CvM", "maxLM", "LMuo", "WDMo", or "maxLMo", specifying the test statistic to be used.
meanCenter	A logical value: should the score contributions be mean centered per parameter?
decorrelate	A logical value: should the score contributions be decorrelated?
impact_groups	A vector indicating impact-group membership for each person.

Details

Author: Dries Debeer

Value

a list with four elements:

statistics A matrix containing all the test statistics.

p A matrix containing the obtained *p*-values.

nSamples The number of samples taken.

DIF_covariate A list containing all the covariate(s) used to order the score contributions, as well as the used test statistics.

See Also

permutation_sctest

Examples

```
data("toydata")
resp <- toydata$resp
group_categ <- toydata$group_categ
it <- toydata$it
discr <- it[,1]
diff <- it[,2]

bootstrap_sctest(resp = resp, DIF_covariate = group_categ, a = discr, b = diff,
decorrelate = FALSE)
```

log_reg *A logistic regression DIF test for MSTs*

Description

This function allows the detection of itemwise DIF for Multistage Tests. It is based on the comparison of three logistic regression models for each item. The first logistic regression model (Model 1) predicts the positiveness of each response solely on the estimated ability parameters. The second logistic regression model (Model 2) predicts the positiveness based on the ability parameters and the membership to the focal and reference group as additive predictor variables. The third model (Model 3) uses the same predictors as Model 2 to predict the positiveness of the responses, but also includes an interaction effect. Three model comparisons are carried out (Models 1/2, Models 1/3, Models 2/3) based on two criteria: The comparison of the Nagelkerke R squared values, and the p-values of a likelihood ratio test.

Usage

```
log_reg(resp, DIF_covariate, theta = NULL)
```

Arguments

resp	A data frame containing the response matrix. Rows correspond to respondents, columns to items.
DIF_covariate	A factor indicating the membership to the reference and focal groups.
theta	A vector of ability estimates for each respondent.

Details

Author: Sebastian Appelbaum, with minor changes by Rudolf Debelak and Dries Debeer

Value

A list with four elements. The first element is the response matrix, the second element is the name of the DIF covariate, and the third element is the name of the test. The fourth element is a data frame where each row corresponds to an item. The columns of this data frame correspond to the following entries:

N The number of responses observed for this item.

overall_chi_sq The chi squared statistic of the likelihood ratio test comparing Model 2 and Model 0.

overall_p_value The p-values of the likelihood ratio test comparing Model 2 and Model 0 as an indicator for the overall DIF effect.

Delta_NagelkerkeR2 The difference of the Nagelkerke R squared values for Model 2 and Model 0.

UDIF_chi_sq The chi squared statistic of the likelihood ratio test comparing Model 1 and Model 0.

UDIF_p_value The p-values of the likelihood ratio test comparing Model 1 and Model 0.

UDIF_Delta_NagelkerkeR2 The difference of the Nagelkerke R squared values for Model 1 and Model 0.

`CDIF_chi_sq` The chi squared statistic of the likelihood ratio test comparing Model 2 and Model 1.

`CDIF_p_value` The p-values of the likelihood ratio test comparing Model 2 and Model 1.

`CDIF_Delta_NagelkerkeR2` The difference of the Nagelkerke R squared values for Model 2 and Model 1.

Examples

```
data("toydata")
resp <- toydata$resp
group_categ <- toydata$group_categ
theta_est <- toydata$theta_est
log_reg(resp, DIF_covariate = factor(group_categ), theta = theta_est)
```

`mstDIF` *A general function to detect differential item functioning (DIF) in multistage tests (MSTs)*

Description

This function allows the application of various methods for the detection of differential item functioning in multistage tests. Currently five methods are implemented: 1. Logistic Regression, 2. mstSIB, 3. analytical score-base tests, 4. a score-based Bootstrap test, 5. a score-based permutation test. The required input differs with regard to the selected DIF test.

Usage

```
## Default S3 method:
mstDIF(resp, DIF_covariate, method, theta = NULL, see = NULL, ...)

## S3 method for class 'AllModelClass'
mstDIF(
  object,
  DIF_covariate,
  method,
  theta = NULL,
  see = NULL,
  theta_method = "WLE",
  ...
)

## S3 method for class 'dRm'
mstDIF(object, DIF_covariate, method, theta = NULL, see = NULL, ...)
```

Arguments

`resp, object` A data frame or matrix containing the response matrix. Rows correspond to respondents, columns to items. Or an object of class SingleGroup-class or MultiGroup-class object as returned by mirt, or a dRm object as returned by the RM function in eRm.

DIF_covariate	A vector of ability estimates for each respondent.
method	A character value indicating the DIF test that should be used. Possible values are "logreg" (Logistic regression), "mstsib" (mstSIB), "bootstrap" (score-based Bootstrap test), "permutation" (score-based) permutation test) and "analytical" (analytical score-based test).
theta	Estimates of the ability parameters.
see	Estimates of the standard error of estimation.
...	Additional, test-specific arguments.
theta_method	Method for estimating the ability parameters if they should be estimated based on the responses. The calculation is carried out by the mirt package. Can be: "WLE" (default), "MAP", "EAP", "ML", "EAPsum", "plausible", "classify".

Details

Author: Rudolf Debelak and Dries Debeer

Value

An object of class mstDIF, which is a list with the following elements:

resp The response matrix as a data frame.

method The used DIF detection method.

test The used test or statistic.

DIF_covariate The person covariate tested for DIF.

DIF_test A list with the DIF-test results.

call The function call.

method_results The complete output of the selected DIF test. Differs depending on the selection.

Methods (by class)

- default: Default mstDIF method
- AllModelClass: mstDIF method for mirt-objects
- dRm: mstDIF method for dRm-objects

See Also

mstDIF-Methods

Examples

```
data("toydata")
resp <- toydata$resp
group_categ <- toydata$group_categ
theta_est <- toydata$theta_est
see_est <- toydata$see_est

res1 <- mstDIF(resp, DIF_covariate = factor(group_categ), method = "logreg",
theta = theta_est)

res2 <- mstDIF(resp, DIF_covariate = factor(group_categ), method = "mstsib",
theta = theta_est, see = see_est)
```

```
summary(res1)
summary(res2)
```

`mstDIF-Methods` *Methods for the mstDIF-class*

Description

`print` and `summary`methods for objects of the `mstDIF-class`, as returned by `mstDIF`. See details for more information about the methods.

Arguments

`x`	an object of class `mstDIF`
`object`	an object of class `mstDIF`
`item_selection`	either `NULL` or an integer vector selecting the item numbers. When `items = NULL` (the default), the DIF test is done for all items.
`DIF_type`	a string that should one or more of "overall", "uniform", "non-uniform", "all".
`ordered`	logical: should the summary be ordered according to the obtained p-values (in ascending order)?
`...`	other arguments passed to the method.

Details

The `print` method prints some basic information about the `mstDIF-class` object.

The `summary` method computes a data frame with a row for each item that was included in the test. The columns are:

item The name of the item

statistic The value for the used statistic per item

p_value The p-value per item

eff_size An effect-size for the DIF-test, if applicable

`mstSIB` *The mstSIB test for MSTs*

Description

This function allows the detection of itemwise DIF using the mstSIB test.

Usage

```
mstSIB(
  resp,
  DIF_covariate,
  theta = NULL,
  see = NULL,
  cellmin = 3,
  pctmin = 0.9,
  NCell = 80
)
```

Arguments

resp	A data frame containing the response matrix. Rows correspond to respondents, columns to items.
DIF_covariate	A vector indicating the membership to the reference (0) and focal (1) groups.
theta	A vector of ability estimates for each respondent.
see	A vector of the standard error of the ability estimates for each respondent.
cellmin	Minimum number of respondents per cell for the focal and reference group. Cells with fewer respondents are discarded.
pctmin	Minimum rate of focal and reference group that should be used for estimating the over ability difference between focal and groups after discarding cells with few respondents.
NCell	The initial number of cells for estimating the overall ability difference between the focal and reference groups.

Details

Author: Mark J. Gierl, with minor changes by Rudolf Debelak and Dries Debeer

Value

A list with four elements. The first element is the response matrix, the second element is the name of the DIF covariate, and the third element is the name of the test. The fourth element is a matrix where each row corresponds to an item. The columns correspond to the following entries:

Beta The estimated weighted ability difference between the focal and reference groups.

Vars The estimation error of the weighted ability difference between the focal and reference groups.

N_R The number of respondents in the reference group.

N_F The number of respondents in the focal group.

NCell The initial number of cells for estimating the overall ability difference between the focal and reference groups.

p_value The p-value of the null hypothesis that the ability difference between the focal and reference groups is 0.

Examples

```
data("toydata")
resp <- toydata$resp
group_categ <- toydata$group_categ
theta_est <- toydata$theta_est
see_est <- toydata$see_est
mstSIB(resp = as.data.frame(resp), theta = theta_est,
DIF_covariate = group_categ, see = see_est)
```

`permutation_sctest` *A score-based DIF test using the permutation approach.*

Description

`permutation_sctest` computes score test to detect DIF in multiple item/parameters with respect to multiple person covariates (`DIF_covariate`). To obtain the p-values a resampling approach is applied. That is, person orders are randomly permuted to sample from the test statistic distribution under the null hypothesis. The functionality is limited to the 1-, 2-, and 3-parameter logistic models. Only DIF with respect to the `a` and `b` parameters are tested for, respectively the item discriminations and the item difficulties.

Usage

```
permutation_sctest(
  resp,
  theta = NULL,
  a = rep(1, length(b)),
  b,
  c = rep(0, length(b)),
  DIF_covariate = NULL,
  parameters = c("per_item", "ab", "a", "b"),
  item_selection = NULL,
  nSamples = 1000,
  theta_method = c("wle", "mle", "eap", "map"),
  slope_intercept = FALSE,
  statistic = "auto",
  meanCenter = TRUE,
  decorrelate = FALSE,
  impact_groups = rep(1, dim(resp)[1])
)
```

Arguments

`resp`	A matrix (or data frame) containing the responses, with the items in the columns.
`theta`	A vector with the true/estimated ability parameters or NULL (the default) which leads to the ability parameters being estimated.
`a`	A vector of item slopes/item discriminations.
`b`	A vector of item locations/item difficulties.
`c`	A vector of pseudo guessing parameters.

DIF_covariate	A list with the person covariate(s) to test for as element(s).
parameters	A character string, either "per_item", "ab", "a", or "b", to specify which parameters should be tested for.
item_selection	A character vector with the column names or an integer vector with the column numbers in the resp, specifying the items for which the test should be computed. When set to NULL (i.t., the default), all the items are tested.
nSamples	An integer value with the number of permutations to be sampled.
theta_method	A character string, either "wle", "mle", "eap", of "map" that specifies the estimator for the ability estimation. Only relevant when theta == NULL.
slope_intercept	A logical value indicating whether the slope-intercept formulation of the 2-/3-PL model should be used.
statistic	A character string, either "auto", "DM", "CvM", "maxLM", "LMuo", "WDMo", or "maxLMo", specifying the test statistic to be used.
meanCenter	A logical value: should the score contributions be mean centered per parameter?
decorrelate	A logical value: should the score contributions be decorrelated?
impact_groups	A vector indicating impact-group membership for each person.

Details

Author: Dries Debeer

Value

a list with four elements:

statistics A matrix containing all the test statistics.

p A matrix containing the obtained *p*-values.

nSamples The number of samples taken.

DIF_covariate A list containing all the covariate(s) used to order the score contributions, as well as the used test statistics.

See Also

bootstrap_sctest

Examples

```
data("toydata")
resp <- toydata$resp
group_categ <- toydata$group_categ
it <- toydata$it
discr <- it[,1]
diff <- it[,2]

permutation_sctest(resp = resp, DIF_covariate = group_categ, a = discr, b = diff,
decorrelate = FALSE)
```

toydata *A Toy Example of 1000 Respondents Working on a Multistage Test*

Description

Data of 1000 respondents working on a multistage test using a (1,2,2) design. The responses were generated based on the 2PL model. Each module consists of 7 items. Data were generated using the mstR package, version 1.2 (https://cran.r-project.org/web/packages/mstR/index.html).

Usage

```
toydata
```

Format

A list with 7 elements:

resp The response matrix, with rows corresponding to respondents and columns corresponding to items.

it A matrix of item parameters. The columns contain the discrimination, difficulty, pseudo-guessing and inattention parameters of the 4PL models. The discrimination parameters were drawn from a N(1,0.2) distribution. The difficulty parameters were drawn from normal distributions. For module 1 (items 1-7), this distributions was N(0,1), for modules 2 and 4 (items 8-14 and 22-28) it was N(1,1) and for modules 3 and 5 (items 15-21 and 29-35) the distribution was N(-1,1).

theta The true ability parameters.

theta_est The ability parameters estimated by the WLE estimator.

group_categ A simulated categorical person covariate. The first 500 respondents belong to group 0, the remaining 500 respondents to group 1.

group_cont A simulated continuous person covariate. It simulates an age covariate, with a uniform distribution between 20 and 60.

see_est The standard errors of the estimated ability parameters.

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