Package 'simCAT'

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Title Implements Computerized Adaptive Testing Simulations

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Description Computerized Adaptive Testing simulations with dichotomic items. Selects items with Maximum Fisher Information method or randomly, with or without constraints (content balancing and item exposure control).

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Imports dplyr,
mirt,
mirtCAT

URL https://github.com/alexandrejaloto/simCAT

BugReports https://github.com/alexandrejaloto/simCAT/issues

R topics documented:

calc.info *Compute item information*

Description

Calculate information of each item in the bank for a theta

Usage

```
calc.info(bank, theta)
```

Arguments

bank	matrix with item parameters (a, b, c)
theta	current theta

Value

A vector with the information of each item

Author(s)

Alexandre Jaloto

calc.prob *Compute probability*

Description

Calculate probability of observing certain answer to a dicotomic item, given a theta

Usage

```
calc.prob(theta, bank, u = 1)
```

Arguments

theta	theta
bank	matrix with item parameters (a, b, c)
u	1 for rigth, 0 for wrong

Value

A vector with the probability of seein determined responsein each item

Author(s)

Alexandre Jaloto

`cat.evaluation` *CAT Evaluation*

Description

Evaluate a CAT simulation

Usage

```
cat.evaluation(results, true.scores, item.name, rmax)
```

Arguments

`results`	list with restults of a CAT simulation from `simCAT`
`true.scores`	true scores
`item.name`	vector with the name of all items in the bank
`rmax`	item maximum exposure rate

Value

a list with two elements.

`evaluate` is a `data.frame`. Each line corresponds to a replication, and the columns are the following variables:

- `rmse` root mean square error between true and estimated score
- `se` standard error of measurement
- `correlation` correlation between true and estimated score
- `bias` bias between true and estimated score
- `overlap` overlap rate
- `min_exp` minimum exposure rate
- `max_exp` maximum exposure rate
- `n_exp0` number of items not administered
- `n_exp_rmax` number of items with exposure rate higher than rmax
- `length_mean` average mean of test length
- `length_sd` standard deviation of test length
- `length_median` average median of test length
- `min_length` minimum test length
- `max_length` maximum test length

`conditional` is a data.frame with the same variables conditioned to the true scores. The `colnames` are the thetas in each decil, that is, `quantile(true.scores,probs = seq(.1,1,length.out = 10))`.

Author(s)

Alexandre Jaloto

`content.balancing` *Content balancing*

Description

Constricts the selection with content balancing (CCAT or MCCAT)

Usage

```
content.balancing(
  bank,
  administered = NULL,
  content.names,
  content.props,
  content.items,
  met.content = "MCCAT"
)
```

Arguments

`bank`	matrix with item parameters (a, b, c)
`administered`	vector with administered items, `NULL` if it is the first item (default)
`content.names`	vector with the contents of the test
`content.props`	desirable proportion of each content in test, in the same order of `content.names`
`content.items`	vector indicating the content of each item
`met.content`	content balancing method • `MCCAT` (default): the function picks all subgroups with proportions most distant from desirable. • `CCAT`: if there is any subgroup without administered item, the function will randomly pick one. If all subgroups has at least one applied item, the function randomly picks one from those with the proportions most distant from desirable. • `MMM`: based on the desired proportions of content, the algorithm builds a sum-one cumulative distribution. Then, a random number with uniform distribution between zero and one is drawn. This number corresponds to an area in the cumulative distribution. It is from the content located in this area that the content will be selected.

Value

A numeric vector with the items that will be excluded for selection. That is, it returns the unavailable items. If all items are available, it returns `NULL`.

Author(s)

Alexandre Jaloto

eap *EAP estimation*

Description

Estimates theta with Expected a Posteriori

Usage

```
eap(pattern, bank)
```

Arguments

pattern	response pattern (0 and 1) with the number of columns corresponding to the number of items
bank	data.frame with item parameters (a, b, c)

Details

40 quadrature points, ranging from -4 to 4. Priori with normal distribution (mean = 0, sd = 1).

Value

data.frame with estimated theta and SE.

Author(s)

Alexandre Jaloto

exposure.rate *Compute exposure rates*

Description

Calculate exposure rate of items in a bank

Usage

```
exposure.rate(previous, item.name)
```

Arguments

previous	list with previous responses. Each element corresponds to a person and has the names of the applied items.
item.name	vector with the name of all items in the bank

Value

`data.frame` with

- `items` name of the items
- `Freq` exposure rate

Author(s)

Alexandre Jaloto

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gen.resp *Generate response pattern*

Description

Generate response pattern based on probability of answering correct a dicotomic item, given a theta and an item bank

Usage

```
gen.resp(theta, bank)
```

Arguments

`theta`	theta
`bank`	matrix with item parameters (a, b, c)

Value

A vector with the probability of seeing determined response in each item

Author(s)

Alexandre Jaloto

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rmse *Root Mean square Error*

Description

Calculate the root mean square error

Usage

```
rmse(true, estimated)
```

Arguments

`true`	true values
`estimate`	estimated values

Value

A numeric vector

Author(s)

Alexandre Jaloto

`select.item` *Select next item*

Description

Select next item to be administered

Usage

```
select.item(
  bank,
  theta,
  administered = NULL,
  sel.method = "MFI",
  cat.type = "variable",
  threshold = 0.3,
  SE,
  acceleration = 1,
  met.weight = "mcclarty",
  max.items = 45,
  content.names = NULL,
  content.props = NULL,
  content.items = NULL,
  met.content = "MCCAT"
)
```

Arguments

`bank`	matrix with item parameters (a, b, c)
`theta`	current theta
`administered`	vector with administered items, `NULL` if it is the first item
`sel.method`	selection method
`cat.type`	CAT with `variable` or `fixed` length. Necessary only for progressive method.
`threshold`	threshold for `cat.type`. Necessary only for progressive method.
`SE`	current standard error. Necessary only for progressive method, with `cat.type = "variable"`
`acceleration`	acceleration parameter. Necessary only for progressive method.
`met.weight`	the procedure to calculate the `progressive`'s weight in variable-length CAT. It can be `"magis"` or `"mcclarty"` (default). See datails.
`max.items`	maximum number of items to be administered. Necessary only for progressive method, with `cat.type = "variable"`

content.names	vector with the contents of the test
content.props	desirable proportion of each content in test, in the same order of content.names
content.items	vector indicating the content of each item
met.content	content balancing method: MCCAT (default), CCAT or MMM. See content.balancing for more information.

Details

In the progressive, the administered item is the one that has the highest weight. The weight of the item i is calculated as following:

$$W_i = (1 - s)R_i + sI_i$$

where R is a random number between zero and the maximum information of an item in the bank for the current theta, I is the item information and s is the importance of the component. As the application progresses, the random component loses importance. There are some ways to calculate s. For fixed-length CAT, Barrada et al. (2008) uses

$$s = 0$$

if it is the first item of the test. For the other administering items,

$$s = \frac{\sum_{f=1}^{q} (f-1)^k}{\sum_{f=1}^{Q} (f-1)^k}$$

where q is the number of the item position in the test, Q is the test length and k is the acceleration parameter. simCAT uses these two equations for fixed-lengh CAT. For variable-length, simCAT can use "magis" (Magis & Barrada, 2017):

$$s = max[\frac{I(\theta)}{I_{stop}}, \frac{q}{M-1}]^k$$

where I(\theta) is the item information for the current theta, I_{stop} is the information corresponding to the stopping error value, and M is the maximum length of the test. simCAT uses as default "mcclarty" (adapted from McClarty et al., 2006):

$$s = (\frac{SE_{stop}}{SE})^k$$

where SE is the standard error for the current theta, SE_{stop} is the stopping error value.

Value

A list with two elements

- item the number o the selected item in item bank
- name name of the selected item (row name)

Author(s)

Alexandre Jaloto

References

Barrada, J. R., Olea, J., Ponsoda, V., & Abad, F. J. (2008). *Incorporating randomness in the Fisher information for improving item-exposure control in CATs*. British Journal of Mathematical and Statistical Psychology, 61(2), 493–513. 10.1348/000711007X230937

Leroux, A. J., & Dodd, B. G. (2016). *A comparison of exposure control procedures in CATs using the GPC model*. The Journal of Experimental Education, 84(4), 666–685. 10.1080/00220973.2015.1099511

Magis, D., & Barrada, J. R. (2017). *Computerized adaptive testing with R: recent updates of the package catR*. Journal of Statistical Software, 76(Code Snippet 1). 10.18637/jss.v076.c01

McClarty, K. L., Sperling, R. A., & Dodd, B. G. (2006). *A variant of the progressive-restricted item exposure control procedure in computerized adaptive testing*. Annual Meeting of the American Educational Research Association, San Francisco

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`simCAT` *CAT simulation*

Description

A CAT simulation with dicotomic items.

Usage

```
simCAT(
  resps,
  bank,
  start.theta = 0,
  sel.method = "MFI",
  cat.type = "variable",
  acceleration = 1,
  met.weight = "mcclarty",
  threshold = 0.3,
  rmax = 1,
  content.names = NULL,
  content.props = NULL,
  content.items = NULL,
  met.content = "MCCAT",
  stop = list(se = 0.3, hypo = 0.015, hyper = Inf)
)
```

Arguments

`resps`	a matrix with responses (0 and 1). The number of columns corresponds to the number of items
`bank`	matrix with item parameters (a, b, c)
`start.theta`	first theta
`sel.method`	item selection method
`cat.type`	CAT with `variable` or `fixed` length Necessary only for progressive method.
`acceleration`	acceleration parameter. Necessary only for progressive method.

met.weight	the procedure to calculate the progressive's weight in variable-length CAT. It can be "magis" or "mcclarty" (default). See datails.
threshold	threshold for cat.type. Necessary only for progressive method.
rmax	item maximum exposure rate
content.names	vector with the contents of the test
content.props	desirable proportion of each content in test, in the same order of content.names
content.items	vector indicating the content of each item
met.content	content balancing method: MCCAT (default), CCAT #' or MMM. See content.balancing for more information.
stop	list with stopping rule and thresholds • se minimum standard error • delta.theta minimum absolute difference between current and previous theta • hypo minimum standard error reduction • hyper minimum standard error reduction after achieving se • info maximum information of an available item • max.items maximum number of items • min.items maximum number of items • fixed fixed number of items

Details

In the progressive, the administered item is the one that has the highest weight. The weight of the item i is calculated as following:

$$W_i = (1 - s)R_i + sI_i$$

where R is a random number between zero and the maximum information of an item in the bank for the current theta, I is the item information and s is the importance of the component. As the application progresses, the random component loses importance. There are some ways to calculate s. For fixed-length CAT, Barrada et al. (2008) uses

$$s = 0$$

if it is the first item of the test. For the other administering items,

$$s = \frac{\sum_{f=1}^{q} (f-1)^k}{\sum_{f=1}^{Q} (f-1)^k}$$

where q is the number of the item position in the test, Q is the test length and k is the acceleration parameter. simCAT uses these two equations for fixed-lengh CAT. For variable-length, simCAT can use "magis" (Magis & Barrada, 2017):

$$s = max[\frac{I(\theta)}{I_{stop}}, \frac{q}{M-1}]^k$$

where I(\theta) is the item information for the current theta, I_{stop} is the information corresponding to the stopping error value, and M is the maximum length of the test. simCAT uses as default "mcclarty" (adapted from McClarty et al., 2006):

$$s = \frac{SE_{stop}}{SE}^k$$

where SE is the standard error for the current theta, SE_{stop} is the stopping error value.

Author(s)

Alexandre Jaloto

References

Barrada, J. R., Olea, J., Ponsoda, V., & Abad, F. J. (2008). *Incorporating randomness in the Fisher information for improving item-exposure control in CATs*. British Journal of Mathematical and Statistical Psychology, 61(2), 493–513. 10.1348/000711007X230937

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`stop.cat` *Check if the CAT ended*

Description

Check if any stopping rule has been achieved

Usage

```
stop.cat(
  rule = list(se = NULL, delta.theta = NULL, hypo = NULL, hyper = NULL, info = NULL,
    max.items = NULL, min.items = NULL, fixed = NULL),
  current = list(se = NULL, delta.theta = NULL, info = NULL, applied = NULL, delta.se =
    NULL)
)
```

Arguments

`rule`	list with stopping rules • `se` minimum standard error • `delta.theta` minimum absolute difference between current and previous theta • `hypo` minimum standard error reduction • `hyper` minimum standard error reduction after achieving `se` • `info` maximum information of an available item • `max.items` maximum number of items • `min.items` maximum number of items • `fixed` fixed number of items
`current`	list with current values • `se` current standard error • `delta.theta` absolute difference between current and previous theta • `info` maximum information of an available item for current theta • `applied` quantitative of applied items • `delta.se` standard error reduction

Value

A list with two elements:

- `stop` `TRUE` if any stopping rule has been achieved
- `convergence` logical. `FALSE` if the CAT stopped because it achieved the maximum number of items. `TRUE` for any other case.

Author(s)

Alexandre Jaloto

Index