

Package ‘Rata’

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Type Package

Title Automated Test Assembly

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Description Automated test assembly of linear and adaptive tests using the mixed-integer programming. The full documentation and tutorials are at <<https://github.com/xluo11/Rata>>.

License GPL (>= 3)

Depends R (>= 3.6.0)

URL <https://github.com/xluo11/Rata>

BugReports <https://github.com/xluo11/Rata/issues>

Imports ggplot2, glpkAPI, lpSolveAPI, Rirt, reshape2, stats

Suggests testthat

RoxygenNote 6.1.1

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Description

`ata` creates a basic ATA model
`ata_relative_objective` adds a relative objective to the model
`ata_absolute_objective` adds an absolute objective to the model
`ata_constraint` adds a constraint to the model
`ata_item_use` limits the minimum and maximum usage for items
`ata_item_enemy` adds an enemy-item constraint to the model
`ata_item_fix` forces an item to be selected or not selected
`ata_solve` solves the MIP model

Usage

```

ata(pool, n_forms = 1, test_len = NULL, max_use = NULL, ...)

ata_relative_objective(x, coef, mode = c("max", "min"), tol = NULL,
  negative = FALSE, forms = NULL, collapse = FALSE,
  internal_index = FALSE)

ata_absolute_objective(x, coef, target, equal_tol = FALSE,
  tol_up = NULL, tol_down = NULL, forms = NULL, collapse = FALSE,
  internal_index = FALSE)

ata_constraint(x, coef, min = NA, max = NA, level = NULL,
  forms = NULL, collapse = FALSE, internal_index = FALSE)

ata_item_use(x, min = NA, max = NA, items = NULL)

ata_item_enemy(x, items)

ata_item_fix(x, items, min = NA, max = NA, forms)

ata_solve(x, solver = c("lpsolve", "glpk"), return_format = c("model",
  "form", "simple"), silent = FALSE, time_limit = 10,
  message = FALSE, ...)

## S3 method for class 'ata'
print(x, ...)

## S3 method for class 'ata'
plot(x, ...)

```

Arguments

pool	the item pool(s), a list of '3pl', 'gpcm', and 'grm' items
n_forms	the number of forms to be assembled
test_len	test length of each form
max_use	maximum use of each item
...	options, e.g. group, common_items, overlap_items
x	an ATA object
coef	the coefficients of the objective function
mode	optimization direction: 'max' for maximization and 'min' for minimization
tol	the tolerance parameter
negative	TRUE when the objective function is expected to be negative
forms	forms where objectives are added. NULL for all forms
collapse	TRUE to collapse into one objective function
internal_index	TRUE to use internal form indices
target	the target values of the objective function
equal_tol	TRUE to force upward and downward tolerance to be equal
tol_up	the range of upward tolerance
tol_down	the range of downward tolerance
min	the lower bound of the constraint
max	the upper bound of the constraint
level	the level of a categorical variable to be constrained
items	a vector of item indices, NULL for all items
solver	use 'lpsolve' for lp_solve 5.5 or 'glpk' for GLPK
return_format	the format of the results: use 'form' to organize results in a list of forms, 'model' to organize results in a list of models, use 'simple' to organize results in data.frame after removing item parameters.
silent	TRUE to mute solution information
time_limit	the time limit in seconds passed along to solvers
message	TRUE to print messages from solvers

Details

The ATA model stores the definitions of a MIP model. When `ata_solve` is called, a real MIP object is created from the definitions.

`ata_obj_relative`: when `mode='max'`, maximize ($y - \text{tol}$), subject to $y \leq \sum(x) \leq y + \text{tol}$; when `mode='min'`, minimize ($y + \text{tol}$), subject to $y - \text{tol} \leq \sum(x) \leq y$. When `negative` is TRUE, $y < 0$, $\text{tol} > 0$. `coef` can be a numeric vector that has the same length with the pool, or a variable name in the pool, or a numeric vector of theta points. When `tol` is NULL, it is optimized; when it's FALSE, ignored; when it's a number, fixed; when it's a range, constrained with lower and upper bounds.

`ata_obj_absolute` minimizes $y_0 + y_1$ subject to $t - y_0 \leq \sum(x) \leq t + y_1$.

When `level` is NA, it is assumed that the constraint is on a quantitative item property; otherwise, a categorical item property. `coef` can be a variable name, a constant, or a numeric vector that has the same size as the pool.

`ata_solve` takes control options in ... For `lpsolve`, see `lpSolveAPI::lp.control.options`. For `glpk`, see `glpkAPI::glpkConstants`

Once the model is solved, additional data are added to the model. `status` shows the status of the solution, `optimum` the optimal value of the objective function found in the solution, `obj_vars` the values of two critical variables in the objective function, `result` the assembly results in a binary matrix, and `items` the assembled items

Value

`ata` returns a `ata` object

`ata_solve` returns a solved `ata` object

Examples

```
## generate a pool of 100 items
library(Rirt)
n_items <- 100
pool <- with(model_3pl_gendata(1, n_items), data.frame(id=1:n_items, a=a, b=b, c=c))
pool$content <- sample(1:3, n_items, replace=TRUE)
pool$time <- round(rlnorm(n_items, log(60), .2))
pool$group <- sort(sample(1:round(n_items/3), n_items, replace=TRUE))
pool <- list('3pl'=pool)

## ex. 1: four 10-item forms, maximize b parameter
x <- ata(pool, 4, test_len=10, max_use=1)
x <- ata_relative_objective(x, "b", "max")
x <- ata_solve(x, time_limit=2)
with(x$items$'3pl', aggregate(b, by=list(form=form), mean))
with(x$items$'3pl', table(form))

## ex. 2: four 10-item forms, minimize b parameter
x <- ata(pool, 4, test_len=10, max_use=1)
x <- ata_relative_objective(x, "b", "min", negative=TRUE)
x <- ata_solve(x, time_limit=5)
with(x$items$'3pl', aggregate(b, by=list(form=form), mean))
with(x$items$'3pl', table(form))

## ex. 3: two 10-item forms, mean(b)=0, sd(b)=1
## content = (3, 3, 4), avg. time = 55--65 seconds
constr <- data.frame(name='content', level=1:3, min=c(3,3,4), max=c(3,3,4), stringsAsFactors=FALSE)
constr <- rbind(constr, c('time', NA, 55*10, 65*10))
x <- ata(pool, 2, test_len=10, max_use=1)
x <- ata_absolute_objective(x, pool$'3pl'$b, target=0*10)
x <- ata_absolute_objective(x, (pool$'3pl'$b-0)^2, target=1*10)
for(i in 1:nrow(constr))
  x <- with(constr, ata_constraint(x, name[i], min[i], max[i], level=level[i]))
x <- ata_solve(x)
```

```
with(x$items$'3pl', aggregate(b, by=list(form=form), mean))
with(x$items$'3pl', aggregate(b, by=list(form=form), sd))
with(x$items$'3pl', aggregate(time, by=list(form=form), mean))
with(x$items$'3pl', aggregate(content, by=list(form=form), function(x) freq(x, 1:3)$freq))

## ex. 4: two 10-item forms, max TIF over (-1, 1), consider item sets
x <- ata(pool, 2, test_len=10, max_use=1, group="group")
x <- ata_relative_objective(x, seq(-1, 1, .5), 'max')
x <- ata_solve(x, time_limit=5)
plot(x)
```

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