Package 'psychotree'

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Title Recursive Partitioning Based on Psychometric Models

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Suggests colorspace, strucchange

Imports graphics, grDevices, grid, stats, Formula

Description Recursive partitioning based on psychometric models,
employing the general MOB algorithm (from package partykit) to obtain
Bradley-Terry trees, Rasch trees, rating scale and partial credit trees, and
MPT trees.

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NeedsCompilation no

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bttree   *Bradley-Terry Trees*

Description

Recursive partitioning (also known as trees) based on Bradley-Terry models.

Usage

```
bttree(formula, data, na.action, cluster,
  type = "loglin", ref = NULL, undecided = NULL, position = NULL, ...)

## S3 method for class 'bttree'
predict(object, newdata = NULL,
  type = c("worth", "rank", "best", "node"), ...)
```

Arguments

formula	A symbolic description of the model to be fit. This should be of type y ~ x1 + x2 where y should be an object of class `paircomp` and x1 and x2 are used as partitioning variables.
data	an optional data frame containing the variables in the model.
na.action	A function which indicates what should happen when the data contain NAs, defaulting to `na.pass`.
cluster	optional vector (typically numeric or factor) with a cluster ID to be employed for clustered covariances in the parameter stability tests.
type	character indicating the type of auxiliary model in bttree and the type of predictions in the predict method, respectively. For the auxiliary model see `btmodel`. For the predict method, four options are available: the fitted "worth" parameter for each alternative, the corresponding "rank", the "best" alternative or the predicted "node" number.
ref, undecided, position	
	arguments for the Bradley-Terry model passed on to `btmodel`.
...	arguments passed to `mob_control`.
object	fitted model object of class "bttree".
newdata	optionally, a data frame in which to look for variables with which to predict. If omitted, the original observations are used.

Details

Bradley-Terry trees are an application of model-based recursive partitioning (implemented in [mob](#))
to Bradley-Terry models for paired comparison data (implemented in [btmodel](#)). Details about the
underlying theory and further explanations of the illustrations in the example section can be found
in Strobl, Wickelmaier, Zeileis (2011).

Various methods are provided for `"bttree"` objects, most of them inherit their behavior from
`"mob"` objects (e.g., `print`, `summary`, etc.). `itempar` behaves analogously to `coef` and extracts
the worth/item parameters from the BT models in the nodes of the tree. The `plot` method employs
the [node_btplot](#) panel-generating function.

Value

An object of S3 class `"bttree"` inheriting from class `"modelparty"`.

References

Strobl C, Wickelmaier F, Zeileis A (2011). Accounting for Individual Differences in Bradley-Terry
Models by Means of Recursive Partitioning. *Journal of Educational and Behavioral Statistics*,
36(2), 135–153. doi: [10.3102/1076998609359791](#)

See Also

[mob](#), [btmodel](#)

Examples

```
o <- options(digits = 4)

## Germany's Next Topmodel 2007 data
data("Topmodel2007", package = "psychotree")

## BT tree
tm_tree <- bttree(preference ~ ., data = Topmodel2007, minsize = 5, ref = "Barbara")
plot(tm_tree, abbreviate = 1, yscale = c(0, 0.5))

## parameter instability tests in root node
if(require("strucchange")) sctest(tm_tree, node = 1)

## worth/item parameters in terminal nodes
itempar(tm_tree)

## CEMS university choice data
data("CEMSChoice", package = "psychotree")
summary(CEMSChoice$preference)

## BT tree
cems_tree <- bttree(preference ~ french + spanish + italian + study + work + gender + intdegree,
  data = CEMSChoice, minsize = 5, ref = "London")
plot(cems_tree, abbreviate = 1, yscale = c(0, 0.5))
itempar(cems_tree)
```

```
options(digits = o$digits)
```

CEMSChoice   *CEMS University Choice Data*

Description

Preferences of 303 students from WU Wien for different CEMS universities.

Usage

```
data("CEMSChoice")
```

Format

A data frame containing 303 observations on 10 variables.

preference Paired comparison of class [paircomp](). Preferences for all 15 paired comparisons from 6 objects: London, Paris, Milano, St. Gallen, Barcelona, Stockholm.

study Factor coding main discipline of study: commerce, or other (economics, business administration, business education).

english Factor coding knowledge of English (good, poor).

french Factor coding knowledge of French (good, poor).

spanish Factor coding knowledge of Spanish (good, poor).

italian Factor coding knowledge of Italian (good, poor).

work Factor. Was the student working full-time while studying?

gender Factor coding gender.

intdegree Factor. Does the student intend to take an international degree?

preference1998 Paired comparison of class [paircomp](). This is like preference but the comparisons between Barcelona an Stockholm are (erroneously) reversed, see below.

Details

Students at Wirtschaftsuniversität Wien (<http://www.wu.ac.at/>) can study abroad visiting one of currently 17 CEMS universities (Community of European Management Schools and International Companies). Dittrich et al. (1998) conduct and analyze a survey of 303 students to examine the student's preferences for 6 universities: London School of Economics, HEC Paris, Università Commerciale Luigi Bocconi (Milano), Universität St. Gallen, ESADE (Barcelona), Handelshögskolan i Stockholm. To identify reasons for the preferences, several subject covariates (including foreign language competence, gender, etc.) have been assessed. Furthermore, several object covariates are attached to preference (and preference1998): the universities' field of specialization (economics, management science, finance) and location (Latin country, or other).

The correct data are available in the online complements to Dittrich et al. (1998). However, the accompanying analysis was based on an erroneous version of the data in which the choices for the last comparison pair (Barcelona : Stockholm) were accidentally reversed. See the corrigendum in

Dittrich et al. (2001) for further details. The variable preference provides the correct data and can thus be used to replicate the analysis from the corrigendum (Dittrich et al. 2001). For convenience, the erroneous version is provided in preference1998 which can therefore be used to replicate the (incorrect) original analysis (Dittrich et al. 1998).

Source

The Royal Statistical Society Datasets Website.

References

Dittrich R, Hatzinger R, Katzenbeisser W (1998). Modelling the Effect of Subject-Specific Covariates in Paired Comparison Studies with an Application to University Rankings, *Journal of the Royal Statistical Society C*, **47**, 511–525.

Dittrich R, Hatzinger R, Katzenbeisser W (2001). Corrigendum: Modelling the Effect of Subject-Specific Covariates in Paired Comparison Studies with an Application to University Rankings, *Journal of the Royal Statistical Society C*, **50**, 247–249.

See Also

paircomp

Examples

```
data("CEMSChoice", package = "psychotree")
summary(CEMSChoice$preference)
covariates(CEMSChoice$preference)
```

DIFSim *Artificial Data with Differential Item Functioning*

Description

Artificial data simulated from a Rasch model and a partial credit model, respectively, where the items exhibit differential item functioning (DIF).

Usage

```
data(DIFSim)
data(DIFSimPC)
```

Format

Two data frames containing 200 and 500 observations, respectively, on 4 variables.

resp an itemresp matrix with binary or polytomous results for 20 or 8 items, respectively.

age age in years.

gender factor indicating gender.

motivation ordered factor indicating motivation level.

Details

The data are employed for illustrations in Strobl et al. (2015) and Komboz et al. (2018). See the manual pages for [raschtree](#) and [pctree](#) for fitting the tree models..

References

Komboz B, Zeileis A, Strobl C (2018). Tree-Based Global Model Tests for Polytomous Rasch Models. *Educational and Psychological Measurement*, **78**(1), 128–166. doi: [10.1177/0013164416664394](#)

Strobl C, Kopf J, Zeileis A (2015). Rasch Trees: A New Method for Detecting Differential Item Functioning in the Rasch Model. *Psychometrika*, **80**(2), 289–316. doi: [10.1007/s1133601393883](#)

See Also

[raschtree](#), [pctree](#)

Examples

```
## data
data("DIFSim", package = "psychotree")
data("DIFSimPC", package = "psychotree")

## summary of covariates
summary(DIFSim[, -1])
summary(DIFSimPC[, -1])

## empirical frequencies of responses
plot(DIFSim$resp)
plot(DIFSimPC$resp)

## histogram of raw scores
hist(rowSums(DIFSim$resp), breaks = 0:20 - 0.5)
hist(rowSums(DIFSimPC$resp), breaks = 0:17 - 0.5)
```

EuropeanValuesStudy   *European Values Study*

Description

A sample of the 1999 European Values Study (EVS) containing an assessment of materialism/postmaterialism in 3584 respondents from 32 countries.

Usage

```
data("EuropeanValuesStudy")
```

Format

A data frame containing 3584 observations on 10 variables.

country Factor coding the country of a respondent.

gender Factor coding gender.

birthyear Numeric. Year of birth.

eduage Numeric. Age when full time education was or will be completed.

marital Factor. Current legal marital status.

employment Ordered factor. Employment and number of working hours.

occupation Factor. What is/was your main job?

income Ordered factor. Income of household in ten categories from 10 percent lowest to 10 percent highest income category.

paircomp Paired comparison of class `paircomp`. Five pairwise choices among four important political goals derived from a double-choice task (see Details).

country2 Factor. Country group according to postmaterialism (see Details).

Details

The data are part of a larger survey conducted in 1999 in 32 countries in Europe (see `http://www.europeanvaluesstudy.eu/`). Vermunt (2003) obtained a sample from 10 percent of the available cases per country, yielding 3584 valid cases.

The item in the 1999 European Values Study questionnaire aiming at recording materialism/postmaterialism reads as follows:

There is a lot of talk these days about what the aims of this country should be for the next ten years. On this card are listed some of the goals which different people would give top priority. If you had to choose, which of the things on this card would you say is most important? And which would be the next most important?

A Maintaining order in the nation
B Giving people more say in important government decisions
C Fighting rising prices
D Protecting freedom of speech

The double-choice task implies a partial ranking of the alternatives and (assuming transitivity) an incomplete set of paired comparisons for each respondent.

The country group according to postmaterialism was derived by Vermunt (2003) using a latent class model, and applied by Lee and Lee (2010) in a tree model.

Source

Latent GOLD Sample Data Sets Website.

References

Lee PH, Yu PLH (2010). Distance-Based Tree Models for Ranking Data. *Computational Statistics and Data Analysis*, **54**, 1672–1682.

Vermunt JK (2003). Multilevel Latent Class Models. *Sociological Methodology*, **33**, 213–239.

See Also

paircomp

Examples

```
## data
data("EuropeanValuesStudy", package = "psychotree")
summary(EuropeanValuesStudy$paircomp)

## Not run:
## Bradley-Terry tree resulting in similar results compared to
## the (different) tree approach of Lee and Lee (2010)
evs <- na.omit(EuropeanValuesStudy)
bt <- bttree(paircomp ~ gender + eduage + birthyear + marital + employment + income + country2,
  data = evs, alpha = 0.01)
plot(bt, abbreviate = 2)

## End(Not run)
```

---

  mpttree   *MPT Trees*

Description

Recursive partitioning (also known as trees) based on multinomial processing tree (MPT) models.

Usage

```
mpttree(formula, data, na.action, cluster, spec, treeid = NULL,
  optimargs = list(control = list(reltol = .Machine$double.eps^(1/1.2),
                                  maxit = 1000)), ...)
```

Arguments

formula	a symbolic description of the model to be fit. This should be of type y ~ x1 + x2 where y should be a matrix of response frequencies and x1 and x2 are used as partitioning variables.
data	an optional data frame containing the variables in the model.
na.action	a function which indicates what should happen when the data contain NAs, defaulting to na.pass.
cluster	optional vector (typically numeric or factor) with a cluster ID to be employed for clustered covariances in the parameter stability tests.
spec, treeid, optimargs	
	arguments for the MPT model passed on to mptmodel.
...	arguments passed to mob_control.

Details

MPT trees (Wickelmaier & Zeileis, 2018) are an application of model-based recursive partitioning (implemented in [mob](#)) to MPT models (implemented in [mptmodel](#)).

Various methods are provided for ″mpttree″ objects, most of them inherit their behavior from ″mob″ objects (e.g., print, summary, etc.). The plot method employs the [node_mptplot](#) panel-generating function.

Value

An object of S3 class ″mpttree″ inheriting from class ″modelparty″.

References

Wickelmaier F, Zeileis A (2018). Using Recursive Partitioning to Account for Parameter Heterogeneity in Multinomial Processing Tree Models. *Behavior Research Methods*, **50**(3), 1217–1233. doi: [10.3758/s134280170937z](#)

See Also

[mob](#), [mptmodel](#).

Examples

```
o <- options(digits = 4)

## Source Monitoring data
data("SourceMonitoring", package = "psychotools")

## MPT tree
sm_tree <- mpttree(y ~ sources + gender + age, data = SourceMonitoring,
  spec = mptspec("SourceMon", .restr = list(d1 = d, d2 = d)))
plot(sm_tree, index = c("D1", "D2", "d", "b", "g"))

## extract parameter estimates
coef(sm_tree)

## parameter instability tests in root node
if(require("strucchange")) sctest(sm_tree, node = 1)

## storage and retrieval deficits in psychiatric patients
data("MemoryDeficits", package = "psychotools")
MemoryDeficits$trial <- ordered(MemoryDeficits$trial)

## MPT tree
sr_tree <- mpttree(cbind(E1, E2, E3, E4) ~ trial + group,
  data = MemoryDeficits, cluster = ID, spec = mptspec("SR2"), alpha = 0.1)

## extract parameter estimates
coef(sr_tree)

options(digits = o$digits)
```

---

node_btplot   *Panel-Generating Function for Visualizing Bradley-Terry Tree Models*

Description

Panel-generating function for visualizing the worth parameters from the nodes in Bradley-Terry tree models.

Usage

```
node_btplot(mobobj, id = TRUE,
  worth = TRUE, names = TRUE, abbreviate = TRUE, index = TRUE, ref = TRUE,
  col = "black", refcol = "lightgray", bg = "white", cex = 0.5, pch = 19,
  xscale = NULL, yscale = NULL, ylines = 1.5)
```

Arguments

mobobj	an object of class "mob" based on Bradley-Terry models fitted by btmodel.
id	logical. Should the node ID be displayed?
worth	logical. Should worth parameters (or their logs) be visualized?
names	logical. Should the names for the objects be displayed?
abbreviate	logical or numeric. Should object names be abbreviated? If numeric this controls the length of the abbreviation.
index	logical. Should different indexes for different stimuli be used?
ref	logical. Should a horizontal line for the reference level be drawn? Alternatively, ref can also be numeric or character to employ a reference level different from that stored in the model object.
col, cex, pch	graphical appearance of plotting symbols.
refcol	line color for reference line (if ref).
bg	color for background filling.
xscale, yscale	x and y axis limits.
ylines	numeric. Number of lines used for y-axis labels.

Details

The panel-generating function node_btplot is called by the plot method for "bttree" objects and does not have to be called by the user directly.

Value

A panel function which can be supplied to the plot method for "mob" objects.

See Also

bttree

---

node_mptplot *Panel-Generating Function for Visualizing MPT Tree Models*

Description

Panel-generating function for visualizing the model parameters from the nodes in MPT tree models.

Usage

```
node_mptplot(mobobj, id = TRUE,
  names = TRUE, abbreviate = TRUE, index = TRUE, ref = TRUE,
  col = "black", linecol = "lightgray", bg = "white", cex = 0.5, pch = 19,
  xscale = NULL, yscale = c(0, 1), ylines = 1.5)
```

Arguments

mobobj	an object of class "mob" based on MPT models fitted by [mptmodel]().
id	logical. Should the node ID be displayed?
names	logical or character. Should the names for the parameters be displayed? If character, this sets the names.
abbreviate	logical or numeric. Should parameter names be abbreviated? If numeric this controls the length of the abbreviation.
index	logical or character. Should different indexes for different parameters be used? If character, this controls the order of labels given in names.
ref	logical. Should a horizontal line for the reference level be drawn?
col, cex, pch	graphical appearance of plotting symbols.
linecol	line color for reference line (if ref).
bg	color for background filling.
xscale, yscale	x and y axis limits.
ylines	numeric. Number of lines used for y-axis labels.

Details

The panel-generating function node_mptplot is called by the plot method for "mpttree" objects and does not have to be called by the user directly.

Value

A panel function which can be supplied to the plot method for "mob" objects.

See Also

[mpttree]()

node_profileplot   *Panel-Generating Function for Visualizing IRT Tree Models*

Description

Panel-generating function for visualizing the parameters from the nodes in Rasch, rating scale or partial credit tree models.

Usage

```
node_profileplot(mobobj, what = c("items", "thresholds", "discriminations"),
  parg = list(type = NULL, ref = NULL, alias = TRUE), id = TRUE,
  names = FALSE, abbreviate = TRUE, index = TRUE, ref = TRUE, col = "black",
  border = col, linecol = "black", refcol = "lightgray", bg = "white",
  cex = 0.5, pch = 21, xscale = NULL, yscale = NULL, ylines = 2, ...)
```

Arguments

mobobj	an object of class "mob" based on rasch models fitted by raschmodel, rating scale models fitted by rsmodel or partial credit models fitted by pcmodel.
what	character, specifying the type of parameters to be plotted.
parg	list of arguments passed over to internal calls of itempar, threshpar or discrpar.
id	logical. Should the node ID be displayed?
names	logical or character. If TRUE, the names of the items are displayed on the x-axis. If FALSE, numbers of items are shown. Alternatively a character vector of the same length as the number of items can be supplied.
abbreviate	logical. Should item names be abbreviated? If numeric this controls the length of the abbreviation.
index	logical. Should different indexes for different items be used?
ref	logical. Should a horizontal line for the reference level be drawn?
col, border, pch, cex	
	graphical appearance of plotting symbols.
linecol, refcol	
	character, specifying the line color to use for the profile lines and reference line, respectively.
bg	color for background filling.
xscale, yscale	x and y axis limits.
ylines	numeric. Number of lines used for y-axis labels.
...	further arguments currently not used.

Details

The panel-generating function node_profileplot is called by the plot method for "raschtree" objects and does not have to be called by the user directly.

Prior to version 0.13-1, node_profileplot was called node_raschplot.

Value

A panel function which can be supplied to the plot method for "mob" objects.

See Also

[raschtree](#)

---

node_regionplot	*Panel-Generating Function for Visualizing Rasch, Rating Scale and Partial Credit Tree Models*

Description

Panel-generating function for visualizing the absolute item threshold parameters from the nodes in rasch, rating scale and partial credit tree models.

Usage

```
node_regionplot(mobobj, names = FALSE, abbreviate = TRUE,
  type = c("mode", "median", "mean"), ref = NULL, ylim = NULL,
  off = 0.1, col_fun = gray.colors, bg = "white", uo_show = TRUE, uo_col = "red",
  uo_lty = 2, uo_lwd = 1.25, ylines = 2)
```

Arguments

mobobj	an object of class "mob" based on rasch models fitted by [raschmodel](#), rating scale models fitted by [rsmodel](#) or partial credit models fitted by [pcmodel](#).
names	logical or character. If TRUE, the names of the items are displayed on the x-axis. If FALSE, numbers of items are shown. Alternatively a character vector of the same length as the number of items can be supplied.
abbreviate	logical. Should item names be abbreviated? If numeric this controls the length of the abbreviation.
type	character, specifying which type of threshold parameters are to be used to mark the category regions per item in the plot (see [regionplot](#) for details).
ref	a vector of labels or position indices of item parameters which should be used as restriction/for normalization. If NULL (the default), all items are used (sum zero restriction). See [threshpar](#) for more details.
ylim	y axis limits
off	numeric, the distance (in scale units) between two item rectangles.
col_fun	function. Function to use for creating the color palettes for the rectangles. Per default gray.colors is used. Be aware that col_fun should accept as first argument an integer specifying the number of colors to create.
bg	color for background filling.
uo_show	logical. If set to TRUE (the default), disordered absolute item threshold parameters are indicated by a horizontal line (only if type is set to "mode").

uo_col	character, color of indication lines (if uo_show).
uo_lty	numeric. Line typ of indication lines (if uo_show).
uo_lwd	numeric. Line width of indication lines (if uo_show).
ylines	numeric. Number of lines used for y-axis labels.

Details

The panel-generating function node_regionplot is called by the plot method of "rstree" and "pctree" objects by default and does not have to be called by the user directly.

See [regionplot](#) for details and references of the drawn region plots and possible values and their meaning for the argument type (taken by node_regionplot).

Prior to version 0.13-1, node_regionplot was called node_effects.

Value

A panel function which can be supplied to the plot method for "mob" objects.

See Also

[raschtree](#), [rstree](#), [pctree](#), [regionplot](#)

---

pctree   *Partial Credit Trees*

Description

Recursive partitioning (also known as trees) based on partial credit models.

Usage

```
pctree(formula, data, na.action, nullcats = c("keep", "downcode", "ignore"),
  reltol = 1e-10,  deriv = c("sum", "diff"), maxit = 100L, ...)

## S3 method for class 'pctree'
predict(object, newdata = NULL,
  type = c("probability", "cumprobability", "mode", "median", "mean",
    "category-information", "item-information", "test-information", "node"),
  personpar = 0, ...)

## S3 method for class 'pctree'
plot(x, type = c("regions", "profile"), terminal_panel = NULL,
  tp_args = list(...), tnex = 2L, drop_terminal = TRUE, ...)
```

Arguments

formula	A symbolic description of the model to be fit. This should be of type y ~ x1 + x2 where y should be a matrix with items in the columns and observations in the rows and x1 and x2 are used as partitioning variables.
data	a data frame containing the variables in the model.
na.action	a function which indicates what should happen when the data contain missing values (NAs).
nullcats	character. How null categories should be treated. See pcmodel for details.
deriv	character. If "sum" (the default), the first derivatives of the elementary symmetric functions are calculated with the sum algorithm. Otherwise ("diff") the difference algorithm (faster but numerically unstable) is used.
reltol, maxit	arguments passed via pcmodel to optim.
...	arguments passed to the underlying functions, i.e., to mob_control for pctree, and to the underlying predict and plot methods, respectively.
object, x	an object of class "raschtree".
newdata	optional data frame with partitioning variables for which predictions should be computed. By default the learning data set is used.
type	character specifying the type of predictions or plot. For the predict method, either just the ID of the terminal "node" can be predicted or some property of the model at a given person parameter (specified by personpar).
personpar	numeric person parameter (of length 1) at which the predictions are evaluated.
terminal_panel, tp_args, tnex, drop_terminal	
	arguments passed to plot.modelparty/plot.party.

Details

Partial credit trees are an application of model-based recursive partitioning (implemented in mob) to partial credit models (implemented in pcmodel).

Various methods are provided for "pctree" objects, most of them inherit their behavior from "modelparty" objects (e.g., print, summary, etc.). For the PCMs in the nodes of a tree, coef extracts all item and threshold parameters except those restricted to be zero. itempar and threshpar extract all item and threshold parameters (including the restricted ones). The plot method by default employs the node_regionplot panel-generating function and the node_profileplot panel-generating function is provided as an alternative.

Value

An object of S3 class "pctree" inheriting from class "modelparty".

References

Komboz B, Zeileis A, Strobl C (2018). Tree-Based Global Model Tests for Polytomous Rasch Models. *Educational and Psychological Measurement*, **78**(1), 128–166. doi: 10.1177/0013164416664394

See Also

[mob](#), [pcmodel](#), [rstree](#), [raschtree](#)

Examples

```
o <- options(digits = 4)

## verbal aggression data from package psychotools
data("VerbalAggression", package = "psychotools")

## use response to the second other-to-blame situation (train)
VerbalAggression$s2 <- VerbalAggression$resp[, 7:12]

## exclude subjects who only scored in the highest or the lowest categories
VerbalAggression <- subset(VerbalAggression, rowSums(s2) > 0 & rowSums(s2) < 12)

## fit partial credit tree model
pct <- pctree(s2 ~ anger + gender, data = VerbalAggression)

## print tree (with and without parameters)
print(pct)
print(pct, FUN = function(x) " *")

## show summary for terminal panel nodes
summary(pct)

## visualization
plot(pct, type = "regions")
plot(pct, type = "profile")

## extract item and threshold parameters
coef(pct)
itempar(pct)
threshpar(pct)

## inspect parameter stability tests in the splitting node
if(require("strucchange")) sctest(pct, node = 1)

options(digits = o$digits)


## partial credit tree on artificial data from Komboz et al. (2018)
data("DIFSimPC", package = "psychotree")
pct2 <- pctree(resp ~ gender + age + motivation, data = DIFSimPC)
plot(pct2, ylim = c(-4.5, 4.5), names = paste("I", 1:8))
```

---

raschtree   *Rasch Trees*

Description

Recursive partitioning (also known as trees) based on Rasch models.

Usage

```
raschtree(formula, data, na.action,
  reltol = 1e-10, deriv = c("sum", "diff", "numeric"), maxit = 100L,
  ...)

## S3 method for class 'raschtree'
predict(object, newdata = NULL,
  type = c("probability", "cumprobability", "mode", "median", "mean",
    "category-information", "item-information", "test-information", "node"),
  personpar = 0, ...)

## S3 method for class 'raschtree'
plot(x, type = c("profile", "regions"), terminal_panel = NULL,
  tp_args = list(...), tnex = 2L, drop_terminal = TRUE, ...)
```

Arguments

formula	A symbolic description of the model to be fit. This should be of type y ~ x1 + x2 where y should be a binary 0/1 item response matrix and x1 and x2 are used as partitioning variables.
data	a data frame containing the variables in the model.
na.action	a function which indicates what should happen when the data contain missing values (NAs).
deriv	character. Which type of derivatives should be used for computing gradient and Hessian matrix? Analytical with sum algorithm ("sum"), analytical with difference algorithm ("diff", faster but numerically unstable), or numerical. Passed to raschmodel.
reltol, maxit	arguments passed via raschmodel to optim.
...	arguments passed to the underlying functions, i.e., to mob_control for raschtree, and to the underlying predict and plot methods, respectively.
object, x	an object of class "raschtree".
newdata	optional data frame with partitioning variables for which predictions should be computed. By default the learning data set is used.
type	character specifying the type of predictions or plot. For the predict method, either just the ID of the terminal "node" can be predicted or some property of the model at a given person parameter (specified by personpar).
personpar	numeric person parameter (of length 1) at which the predictions are evaluated.
terminal_panel, tp_args, tnex, drop_terminal	
	arguments passed to plot.modelparty/plot.party.

Details

Rasch trees are an application of model-based recursive partitioning (implemented in [mob](#)) to Rasch models (implemented in [raschmodel](#)).

Various methods are provided for "raschtree" objects, most of them inherit their behavior from "modelparty" objects (e.g., `print`, `summary`, etc.). For the Rasch models in the nodes of a tree, `coef` extracts all item parameters except the first one which is always restricted to be zero. `itempar` extracts all item parameters (including the first one) and by default restricts their sum to be zero (but other restrictions can be used as well). The `plot` method by default employs the [node_profileplot](#) panel-generating function and the [node_regionplot](#) panel-generating function is provided as an alternative.

Rasch tree models are introduced in Strobl et al. (2015), whose analysis for the [SPISA](#) data is replicated in `vignette("raschtree", package = "psychotree")`. Their illustration employing artificial data is replicated below.

Value

An object of S3 class "raschtree" inheriting from class "modelparty".

References

Strobl C, Kopf J, Zeileis A (2015). Rasch Trees: A New Method for Detecting Differential Item Functioning in the Rasch Model. *Psychometrika*, **80**(2), 289–316. doi: [10.1007/s1133601393883](#)

See Also

[mob](#), [raschmodel](#), [rstree](#), [pctree](#)

Examples

```
o <- options(digits = 4)

## artificial data
data("DIFSim", package = "psychotree")

## fit Rasch tree model
rt <- raschtree(resp ~ age + gender + motivation, data = DIFSim)
plot(rt)

## extract item parameters
itempar(rt)

## inspect parameter stability tests in all splitting nodes
if(require("strucchange")) {
sctest(rt, node = 1)
sctest(rt, node = 2)
}

## highlight items 3 and 14 with DIF
ix <- rep(1, 20)
ix[c(3, 14)] <- 2
```

```
plot(rt, ylines = 2.5,  cex = c(0.4, 0.8)[ix],
  pch = c(19, 19)[ix], col = gray(c(0.5, 0))[ix])

options(digits = o$digits)
```

---

rstree   *Rating Scale Trees*

Description

Recursive partitioning (also known as trees) based on rating scale models.

Usage

```
rstree(formula, data, na.action, reltol = 1e-10,
  deriv = c("sum", "diff"), maxit = 100L, ...)

## S3 method for class 'rstree'
predict(object, newdata = NULL,
  type = c("probability", "cumprobability", "mode", "median", "mean",
    "category-information", "item-information", "test-information", "node"),
  personpar = 0, ...)

## S3 method for class 'rstree'
plot(x, type = c("regions", "profile"), terminal_panel = NULL,
  tp_args = list(...), tnex = 2L, drop_terminal = TRUE, ...)
```

Arguments

formula	A symbolic description of the model to be fit. This should be of type y ~ x1 + x2 where y should be a matrix with items in the columns and observations in the rows and x1 and x2 are used as partitioning variables. Additionally each item (column) should have the same maximum value (see [pctree](#) for a way to handle variable maximum values).
data	a data frame containing the variables in the model.
na.action	a function which indicates what should happen when the data contain missing values (NAs).
deriv	character. If "sum" (the default), the first derivatives of the elementary symmetric functions are calculated with the sum algorithm. Otherwise ("diff") the difference algorithm (faster but numerically unstable) is used.
reltol, maxit	arguments passed via [rsmodel](#) to [optim](#).
...	arguments passed to the underlying functions, i.e., to [mob_control](#) for rstree, and to the underlying predict and plot methods, respectively.
object, x	an object of class "raschtree".
newdata	optional data frame with partitioning variables for which predictions should be computed. By default the learning data set is used.

type	character specifying the type of predictions or plot. For the predict method, either just the ID of the terminal "node" can be predicted or some property of the model at a given person parameter (specified by personpar).
personpar	numeric person parameter (of length 1) at which the predictions are evaluated.
terminal_panel, tp_args, tnex, drop_terminal	
	arguments passed to plot.modelparty/plot.party.

Details

Rating scale trees are an application of model-based recursive partitioning (implemented in mob) to rating scale models (implemented in rsmodel).

Various methods are provided for "rstree" objects, most of them inherit their behavior from "mob" objects (e.g., print, summary, etc.). For the rating scale models in the nodes of a tree, coef extracts all item parameters. The plot method employs the node_regionplot panel-generating function by default.

Various methods are provided for "rstree" objects, most of them inherit their behavior from "modelparty" objects (e.g., print, summary, etc.). For the RSMs in the nodes of a tree, coef extracts all item and threshold parameters except those restricted to be zero. itempar and threshpar extract all item and threshold parameters (including the restricted ones). The plot method by default employs the node_regionplot panel-generating function and the node_profileplot panel-generating function is provided as an alternative.

Value

An object of S3 class "rstree" inheriting from class "modelparty".

References

Komboz B, Zeileis A, Strobl C (2018). Tree-Based Global Model Tests for Polytomous Rasch Models. *Educational and Psychological Measurement*, **78**(1), 128–166. doi: 10.1177/0013164416664394

See Also

mob, rsmodel, pctree, raschtree

Examples

```
## IGNORE_RDIFF_BEGIN
o <- options(digits = 4)

## verbal aggression data from package psychotools
data("VerbalAggression", package = "psychotools")

## responses to the first other-to-blame situation (bus)
VerbalAggression$s1 <- VerbalAggression$resp[, 1:6]

## exclude subjects who only scored in the highest or the lowest categories
VerbalAggression <- subset(VerbalAggression, rowSums(s1) > 0 & rowSums(s1) < 12)

## fit rating scale tree model for the first other-to-blame situation
```

```
rst <- rstree(s1 ~ anger + gender, data = VerbalAggression)

## print tree (with and without parameters)
print(rst)
print(rst, FUN = function(x) " *")

## show summary for terminal panel nodes
summary(rst)

## visualization
plot(rst, type = "regions")
plot(rst, type = "profile")

## extract item and threshold parameters
coef(rst)
itempar(rst)
threshpar(rst)

## inspect parameter stability tests in all splitting nodes
if(require("strucchange")) {
sctest(rst, node = 1)
sctest(rst, node = 2)
}

options(digits = o$digits)
## IGNORE_RDIFF_END
```

SPISA *SPIEGEL Studentenpisa Data (Subsample)*

Description

A subsample from the general knowledge quiz "Studentenpisa" conducted online by the German weekly news magazine SPIEGEL. The data contain the quiz results from 45 questions as well as sociodemographic data for 1075 university students from Bavaria.

Usage

```
data("SPISA")
```

Format

A data frame containing 1075 observations on 6 variables.

spisa matrix with 0/1 results from 45 questions in the quiz (indicating wrong/correct answers).

gender factor indicating gender.

age age in years.

semester numeric indicating semester of university enrollment.

elite factor indicating whether the university the student is enrolled in has been granted "elite" status by the German "excellence initiative".

spon ordered factor indicating frequency of accessing the SPIEGEL online (SPON) magazine.

Details

An online quiz for testing one's general knowledge was conducted by the German weekly news magazine SPIEGEL in 2009. Overall, about 700,000 participants answered the quiz and a set of sociodemographic questions. The general knowledge quiz consisted of a total of 45 items from five different topics: politics, history, economy, culture and natural sciences. For each topic, four different sets of nine items were available, that were randomly assigned to the participants. A thorough analysis and discussion of the original data set is provided in Trepte and Verbeet (2010).

Here, we provide the subsample of university students enrolled in the federal state of Bavaria, who had been assigned questionnaire number 20 (so that all subjects have answered the same set of items). Excluding all incomplete records, this subsample contains 1075 observations.

The data are analyzed in Strobl et al. (2010), whose analysis is replicated in `vignette("raschtree",package = "psychotree")`.

The full list of items in questionnaire 20 is given below.

Politics:
Who determines the rules of action in German politics according to the constitution? – The Bundeskanzler (federal chancellor).
What is the function of the second vote in the elections to the German Bundestag (federal parliament)? – It determines the allocation of seats in the Bundestag.
How many people were killed by the RAF (Red Army Faction)? – 33.
Where is Hessen (i.e., the German federal country Hesse) located? – (Indicate location on a map.)
What is the capital of Rheinland-Pfalz (i.e., the German federal country Rhineland-Palatinate)? – Mainz.
Who is this? – (Picture of Horst Seehofer.)
Which EU institution is elected in 2009 by the citizens of EU member countries? – European Parliament.
How many votes does China have in the UNO general assembly? – 1.
Where is Somalia located? – (Indicate location on a map.)

History:
The Roman naval supremacy was established through... – ... the abolition of Carthage.
In which century did the Thirty Years' War take place? – The 17th century.
Which form of government is associated with the French King Louis XIV? – Absolutism.
What island did Napoleon die on in exile? – St. Helena.
How many percent of the votes did the NSDAP receive in the 1928 elections of the German Reichstag? – About 3 percent.
How many Jews were killed by the Nazis during the Holocaust? – About 6 Million.
Who is this? – (Picture of Johannes Rau, former German federal president.)
Which of the following countries is not a member of the EU? – Croatia.
How did Mao Zedong expand his power in China? – The Long March.

Economy:
Who is this? – (Picture of Dieter Zetsche, CEO of Mercedes-Benz.)
What is the current full Hartz IV standard rate (part of the social welfare) for adults? – 351 Euro.
What was the average per capita gross national product in Germany in 2007? – About 29,400 Euro.\

What is a CEO? – A Chief Executive Officer.
What is the meaning of the hexagonal "organic" logo? – Synthetic pesticides are prohibited.
Which company does this logo represent? – Deutsche Bank.
Which German company took over the British automobile manufacturers Rolls-Royce? – BMW.
Which internet company took over the media group Time Warner? – AOL.
What is the historic meaning of manufactures? – Manufactures were the precursors of industrial mass production.

Culture:
Which painter created this painting? – Andy Warhol.
What do these four buildings have in common? – All four were designed by the same architects.
Roman numbers: What is the meaning of CLVI? – 156.
What was the German movie with the most viewers since 1990? – Der Schuh des Manitu.
In which TV series was the US president portrayed by an African American actor for a long time? – 24.
What is the name of the bestselling novel by Daniel Kehlmann? – Die Vermessung der Welt (Measuring The World).
Which city is the setting for the novel 'Buddenbrooks'? – Lübeck.
In which city is this building located? – Paris.
Which one of the following operas is not by Mozart? – Aida.

Natural sciences:
Why does an ice floe not sink in the water? – Due to the lower density of ice.
What is ultrasound not used for? – Radio.
Which sensory cells in the human eye make color vision possible? – Cones.
What is also termed Trisomy 21? – Down syndrome.
Which element is the most common in the Earth's atmosphere? – Nitrogen.
Which kind of tree does this leaf belong to? – Maple.
Which kind of bird is this? – Blackbird.
Where is the stomach located? – (Indicate location on a map of the body.)
What is the sum of interior angles in a triangle? – 180 degrees.

References

Strobl C, Kopf J, Zeileis A (2015). Rasch Trees: A New Method for Detecting Differential Item Functioning in the Rasch Model. *Psychometrika*, **80**(2), 289–316. doi: 10.1007/s1133601393883

SPIEGEL Online (2009). Studentenpisa – Alle Fragen, alle Antworten. In German. Accessed 2010-10-26. https://www.spiegel.de/lebenundlernen/uni/studentenpisa-alle-fragen-alle-antworten-a-620101.html

Trepte S, Verbeet M (2010). Allgemeinbildung in Deutschland – Erkenntnisse aus dem SPIEGEL-Studentenpisa-Test. ISBN 978-3-531-17218-7. VS Verlag, Wiesbaden.

See Also

raschtree

Examples

```
## data
```

```
data("SPISA", package = "psychotree")

## summary of covariates
summary(SPISA[,-1])

## histogram of raw scores
hist(rowSums(SPISA$spisa), breaks = 0:45 + 0.5)

## Not run:
## See the following vignette for a tree-based DIF analysis
vignette("raschtree", package = "psychotree")

## End(Not run)
```

Topmodel2007   *Attractiveness of Germany's Next Topmodels 2007*

Description

Preferences of 192 respondents judging the attractiveness of the top six contestants of the TV show *Germany's Next Topmodel 2007* (second cycle).

Usage

```
data("Topmodel2007")
```

Format

A data frame containing 192 observations on 6 variables.

preference Paired comparison of class [paircomp](). Preferences for all 15 paired comparisons from 6 contestants: Barbara, Anni, Hana, Fiona, Mandy, and Anja.

gender Factor coding gender.

age Integer. Age of the respondents in years.

q1 Factor. Do you recognize the women on the pictures?/Do you know the TV show Germany's Next Topmodel?

q2 Factor. Did you watch Germany's Next Topmodel regularly?

q3 Factor. Did you watch the final show of Germany's Next Topmodel?/Do you know who won Germany's Next Topmodel?

Details

Germany's Next Topmodel is a German casting television show (based on a concept introduced in the United States) hosted by Heidi Klum (see Wikipedia 2009). The second season of the show aired March–May 2007.

A survey was conducted at the Department of Psychology, Universität Tübingen, in 2007 shortly after the final show. The sample was stratified by gender and age (younger versus older than 30 years) with 48 participants in each group.

Digital photographs (resolution 303 times 404 pixels) of the top six contestants were available from the ProSieben web page (<http://www.prosieben.de/>) at the time of the survey. The photos were selected to be comparable, showing the contestant's face and the upper part of the body, all women being casually dressed.

Participants were presented with all 15 pairs of photographs. On each trial, their task was to judge which of the two women on the photos was the more attractive. In order to assess the participants' expertise, additional questions regarding their familiarity with the show were asked after the pairwise comparisons were completed.

The actual ranking, as resulting from sequential elimination during the course of the show, was (from first to sixth place): Barbara, Anni, Hana, Fiona, Mandy, Anja.

References

Wikipedia (2009). Germany's Next Topmodel – Wikipedia, The Free Encyclopedia. <http://en.wikipedia.org/wiki/Germany's_Next_Topmodel>, accessed 2009-02-06.

See Also

paircomp

Examples

```
data("Topmodel2007", package = "psychotree")
summary(Topmodel2007$preference)
xtabs(~ gender + I(age < 30), data = Topmodel2007)
```

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