Package ‘rpms’

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Type Package

Title Recursive Partitioning for Modeling Survey Data

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Description Functions to allow users to build and analyze design consistent tree and random forest models using survey data from a complex sample design. The tree model algorithm can fit a linear model to survey data in each node obtained by recursively partitioning the data. The splitting variables and selected splits are obtained using a randomized permutation test procedure which adjusted for complex sample design features used to obtain the data. Likewise the model fitting algorithm produces design-consistent coefficients to any specified least squares linear model between the dependent and independent variables used in the end nodes. The main functions return the resulting binary tree or random forest as an object of ``rpms'' or ``rpms_forest'' type. The package also provides methods modeling a ``boosted'' tree or forest model and a tree model for zero-inflated data as well as a number of functions and methods available for use with these object types.

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Contents

`rpms-package` *Recursive Partitioning for Modeling Survey Data (rpms)*

Description

This package provides a function `rpms` to produce an `rpms` object and method functions that operate on them. The `rpms` object is a representation of a regression tree achieved by recursively partitioning the dataset, fitting the specified linear model on each node separately. The recursive partitioning algorithm has an unbiased variable selection and accounts for the sample design. The algorithm accounts for one-stage of stratification and clustering as well as unequal probability of selection. There are also functions for producing random forest estimator (a list of `rpms` objects), a boosted regression tree and tree based zero-inflated model.

`boxes` *boxes*

Description

returns end boxes that partition the data

Usage

```
boxes(x)
```

Arguments

`x`	`rpms` object

Value

data.frame including end_node, sample size, splits, and values for each end node

`box_ind` *box_ind*

Description

For each row of data, returns a vector indicators whether observation is in that box or not

Usage

```
box_ind(x, newdata)
```

Arguments

`x`	`rpms` object
`newdata`	dataframe containing the variables used for the recursive partitioning.

Value

Matrix where each row is a vector of indicators whether observation is in box or not.

CE *CE Consumer expenditure data 2015*

Description

A dataset containing consumer unit characteristics, assets and expenditure data from the Bureau of Labor Statistics' Consumer Expenditure Survey public use interview data file.

Usage

```
CE
```

Format

A data frame with 68,415 observations on 47 variables:

Sample-design information

NEWID Consumer unit identifying variable, constructed using the first seven digits of NEWID BLS derived

PSU Primary Sampling Unit code for the 21 biggest clusters

CID Cluster Identifier for all clusters, (created using PSU, REGION, STATE, and POPSIZE) not part of CE data

QINTRVMO Month for which data was collected

FINLWT21 Final sample weight to make inference to total population

Location of Consumer Unit

STATE State FIPS code

REGION Region code: 1 Northeast; 2 Midwest; 3 South; 4 West

BLS_URBN Urban = 1, Rural = 2

POPSIZE Population size class of PSU: 1-biggest 5-smallest

Housing and transportation

CUTENURE Housing tenure: 1 Owned with mortgage; 2 Owned without mortgage 3 Owned mortgage not reported; 4 Rented; 5 Occupied without payment of cash rent; 6 Student housing

ROOMSQ Number of rooms, including finished living areas and excluding all baths

BATHRMQ Number of bathrooms

BEDROOMQ Number of bedrooms

VEHQ Number of owned vehicles

VEHQL Number of leased vehicles

Family Information

FAM_TYPE CU code based on relationship of members to reference person (children incldue blood-related, step and adopted): 1 Married Couple only; 2 Married Couple, children (oldest < 6 years old); 3 Married Couple, children (oldest 6 to 17 years old); 4 Married Couple, children (oldest > 17 years old); 5 All other Married Couple CUs 6 One parent (male), children (at least one child < 18 years old); 7 One parent (female), children (at least one child < 18 years old); 8 Single consumers; 9 Other CUs

FAM_SIZE Number of members in CU

PERSLT18 Number of people <18 yrs old

PERSOT64 Number of people >64 yrs old

NO_EARNR Number of earners

Primary Earner Information

AGE Age of primary earner

EDUCA Education level coded: 1 None; 2 1st-8th Grade; 3 some HS; 4 HS; 5 Some college; 6 AA degree; 7 Bachelors degree; 8 Advanced degree

SEX Gender Code: F (Female); M (Male)

MARITAL Marital Status Coded: 1 Married; 2 Widowed; 3 Divorced; 4 Separated; 5 Never Married

MEMBRACE Race code: 1 White; 2 Black; 3 Native American; 4 Asian; 5 Pacific Islander; 6 Multi-race

HORIGIN Hispanic, Latino, or Spanish origin? Y (Yes); N (No)

ARM_FORC Member of armed forces? Y (Yes); N (No)

IN_COLL Currently enrolled in college? Full (full time); Part (part time); No

Labor Status of Primary Earner

EARNER Earn income: Y (Yes); N (No)

EARNTYPE 1 Full time all year; 2 Part time all year; 3 Full time part of the year; 2 Part time part of the year;

OCCUCODE The job in which the member received the most earnings during the past 12 months fits best in the following category: 01 Administrator, manager; 02 Teacher; 03 Professional Administrative support, technical, sales; 04 Administrative support, including clerical; 05 Sales, retail; 06 Sales, business goods and services; 07 Technician; 08 Protective service; 09 Private household service; 10 Other service; 11 Machine operator, assembler, inspector; 12 Transportation operator; 13 Handler, helper, laborer; 14 Mechanic, repairer, precision production; 15 Construction, mining; 16 Farming; 17 Forestry, fishing, grounds-keeping; 18 Armed forces

INCOMEY Type of employment: 1 An employee of a PRIVATE company, business, or individual 2 A Federal government employee 3 A State government employee 4 A local government employee 5 Self-employed in OWN business, professional practice or farm 6 Working WITHOUT PAY in family business or farm

INCNONWK Reason did not work during the past 12 months: 1 Retired; 2 Home maker; 3 School; 4 health; 5 Unable to find work; 6 Doing something else

Income

FINCBTAX Amount of CU income before taxes in past 12 months

SALARYX Amount of wage or salary income received in past 12 months, before any deductions

SOCRRX Amount income received from Social Security and Railroad Retirement in past 12 months

Assetts and Liabilities

IRAX Total value of all retirement accounts

LIQUIDX Value of liquid assets

STOCKX Total value of all directly-held stocks, bonds

STUDNTX Amount owed on all student loans

Expenditures

TOTEXPCQ Total expenditures for current quarter

TOTXEST Total taxes paid (estimated)

EHOUSNGC Total expenditures for housing paid this quarter

HEALTHCQ Expenditures on health care quarter

FOODCQ Expenditure on food this quarter

TOBACCCQ Tobacco and smoking supplies this quarter

FOOTWRCQ Expenditure on footware1 this quarter

end describe

Source

https://www.bls.gov/cex/pumd_data.htm

`end_nodes` *end_nodes*

Description

Either a vector of end-node labels for each opbservation in newdata or a vector of the endnodes in the tree model if newdata is not provided.

Usage

```
end_nodes(object, newdata = NULL)
```

Arguments

`object`	`rpms` object
`newdata`	data.frame

Value

vector of end_node labels

Examples

```
{
# model mean of retirement account value for households with reported
# retirment account values > 0 using a binary tree while accounting for
# clusterd data and sample weights.

s1<- which(CE$IRAX > 0)
r1 <-rpms(IRAX~EDUCA+AGE+BLS_URBN, data = CE[s1,],  weights=~FINLWT21, clusters=~CID)

 end_nodes(r1)
}
```

`grow_rpms` *grow_rpms*

Description

grow an rpms tree from a given node

Usage

```
grow_rpms(
  x,
  node,
  data,
  weights = ~1,
  strata = ~1,
  clusters = ~1,
  pval = NA,
  bin_size = NA
)
```

Arguments

`x`	`rpms` object
`node`	node from which to grow tree further
`data`	data.frame that includes variables used in rp_equ, e_equ, and design information
`weights`	formula or vector of sample weights for each observation
`strata`	formula or vector of strata labels
`clusters`	formula or vector of cluster labels
`pval`	numeric p-value used to reject null hypothesis in permutation test
`bin_size`	numeric minimum number of observations in each node

Value

rpms tree expanded from node.

in_node *in_node*

Description

Get index of elements in dataframe that are in the specified end-node of an rpms object. A "which" function for end-nodes.

Usage

```
in_node(x, node, data)
```

Arguments

x	rpms object
node	integer label of the desired end-node.
data	dataframe containing the variables used for the recursive partitioning.

Value

vector of indexes for observations in the end-node.

Examples

```
{
# model mean of retirement account value for households with reported
# retirment account values > 0 using a binary tree while accounting for
# clusterd data and sample weights.

s1<- which(CE$IRAX > 0)
r1 <-rpms(IRAX~EDUCA+AGE+BLS_URBN, data = CE[s1,],  weights=~FINLWT21, clusters=~CID)

# Get summary statistics of CUTENURE for households in end-nodes 7 and 8 of the tree

if(7 %in% end_nodes(r1))
  summary(CE$CUTENURE[in_node(node=7, r1, data=CE[s1,])])
if(8 %in% end_nodes(r1))
  summary(CE$CUTENURE[in_node(node=8, r1, data=CE[s1,])])
}
```

`linearize` *linearize*

Description

returns a linerized version of the splits. The coefficients represent the effect that each split has on the mean

Usage

```
linearize(x, data, weights = ~1, strata = ~1, clusters = ~1, type = "part")
```

Arguments

`x`	`rpms` object
`data`	data.frame
`weights`	formula or vector of sample weights for each observation
`strata`	formula or vector of strata labels
`clusters`	formula or vector of cluster labels
`type`	is on of "part" or "lin"

Value

data.frame including splits and estimates for the coefficient and their standard errors

`node_plot` *node_plot*

Description

plots end-node of object of class `rpms`

Usage

```
node_plot(object, node, data, variable = NA, ...)
```

Arguments

`object`	`rpms` object
`node`	integer label of the desired end-node.
`data`	data.frame that includes variables used in rp_equ, e_equ, and design information
`variable`	string name of variable in data to use as x-axis in plot
`...`	further arguments passed to plot function.

Examples

```
{

# model mean of retirement account value for households with reported
# retirment account values > 0 using a binary tree while accounting for
# clusterd data and sample weights.

s1<- which(CE$IRAX > 0)
r1 <-rpms(IRAX~EDUCA+AGE+BLS_URBN, data = CE[s1,],  weights=~FINLWT21, clusters=~CID)

# plot node 6 if it is an end-node of the tree
if(6 %in% end_nodes(r1))
  node_plot(object=r1, node=6, data=CE[s1,])

# plot node 6 if it is an end-node of the tree
if(8 %in% end_nodes(r1))
  node_plot(object=r1, node=8, data=CE[s1,])

}
```

`predict.rpms` *predict.rpms*

Description

Predicted values based on `rpms` object

Usage

```
## S3 method for class 'rpms'
predict(object, newdata, ...)
```

Arguments

`object`	Object inheriting from `rpms`
`newdata`	data frame with variables to use for predicting new values.
`...`	further arguments passed to or from other methods.

Value

vector of predicticed values for each row of newdata

Examples

```
{

# get rpms model of mean Soc Security income for families headed by a
# retired person by several factors
r1 <-rpms(SOCRRX~EDUCA+AGE+BLS_URBN+REGION,
          data=CE[which(CE$INCNONWK==1),], clusters=~CID)

r1

# first 10 predicted means
predict(r1, CE[10:20, ])

}
```

---

predict.rpms_boost *predict.rpms_boost*

Description

Predicted values based on `rpms_boost` object

Usage

```
## S3 method for class 'rpms_boost'
predict(object, newdata, ...)
```

Arguments

`object`	Object inheriting from `rpms_boost`
`newdata`	data frame with variables to use for predicting new values.
`...`	further arguments passed to or from other methods.

Value

vector of predicticed values for each row of newdata

predict.rpms_forest *predict.rpms_forest*

Description

Gets predicted values given new data based on `rpms_forest` model.

Usage

```
## S3 method for class 'rpms_forest'
predict(object, newdata, ...)
```

Arguments

`object`	Object inheriting from `rpms_forest`
`newdata`	data frame with variables to use for predicting new values.
`...`	further arguments passed to or from other methods.

Value

vector of predicticed values for each row of newdata

predict.rpms_proj *predict.rpms_proj*

Description

Predicted values based on `rpms_zinf` model

Usage

```
## S3 method for class 'rpms_proj'
predict(object, newdata, ...)
```

Arguments

`object`	Object inheriting from `rpms_zinf`
`newdata`	data frame with variables to use for predicting new values.
`...`	further arguments passed to or from other methods.

Value

vector of predicticed values for each row of newdata

predict.rpms_zinf *predict.rpms_zinf*

Description

Predicted values based on rpms_zinf model

Usage

```
## S3 method for class 'rpms_zinf'
predict(object, newdata, ...)
```

Arguments

object	Object inheriting from rpms_zinf
newdata	data frame with variables to use for predicting new values.
...	further arguments passed to or from other methods.

Value

vector of predicticed values for each row of newdata

print.rpms *print.rpms*

Description

print method for class rpms

Usage

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

Arguments

x	rpms object
...	further arguments passed to or from other methods.

`print.rpms_forest` *print.rpms_forest*

Description

Prints information for a given `rpms_forest` model.

Usage

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

Arguments

`x`	Object inheriting from `rpms_forest`
`...`	further arguments passed to or from other methods.

Value

vector of predicticed values for each row of newdata

`print.rpms_zinf` *print.rpms_zinf*

Description

print method for class `rpms_zinf`

Usage

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

Arguments

`x`	`rpms_zinf` object
`...`	further arguments passed to or from other methods.

prune_rpms *prune_rpms*

Description

prune rpms tree to given node

Usage

```
prune_rpms(x, node)
```

Arguments

x	rpms object
node	number of node to prune to.

Value

subtree ending clipping off any splits after given node.

qtree *qtree*

Description

Code to write a latex qtree plot takes a rpm frame and returns latex code to produce qtree uses linearize as a guide Produces text code to produce tree structure in tex document Requires using LaTex packages and the following commands in preamble of LaTex doc: \usepackage{lscape} and \usepackage{tikz-qtree}

Usage

```
qtree(
  t1,
  title = NULL,
  label = NA,
  caption = "",
  digits = 2,
  s_size = TRUE,
  scale = 1,
  lscape = FALSE,
  subnode = 1
)
```

Arguments

`t1`	rpms object created by rpms function
`title`	string for the top node of the tree
`label`	string used for labeling the tree figure
`caption`	string used for caption
`digits`	integer number of displayed digits
`s_size`	boolean indicating whether or not to include sample size
`scale`	numeric factor for scaling size of tree
`lscape`	boolean to display tree in landscape mode
`subnode`	starting node of subtree to plot

Examples

```
{
# model mean of retirement account value for households with reported
# retirment account values > 0 using a binary tree while accounting for
# clusterd data and sample weights.

s1<- which(CE$IRAX > 0)
r1 <-rpms(IRAX~EDUCA+AGE+BLS_URBN, data = CE[s1,],  weights=~FINLWT21, clusters=~CID)

# get Latex code
qtree(r1)

}
```

`r2stat` *r2*

Description

Returns the estimated R^2 statistic for determining the fit of the given model to the data

Usage

```
r2stat(t1, data, adjusted = TRUE)
```

Arguments

`t1`	Object inheriting from `rpms` `rpms_forest` `rpms_boost` or `rpms_zinf`
`data`	data frame with variables used to estimate model
`adjusted`	TRUE/FALSE whether to compute adjusted R^2

Value

R^2 statistic computed using the model and provided data

rpms *rpms*

Description

main function producing a regression tree using variables from rp_equ to partition the data and fit the model e_equ on each node. Currently only uses data with complete cases of continuous variables.

Usage

```
rpms(
  rp_equ,
  data,
  weights = ~1,
  strata = ~1,
  clusters = ~1,
  e_equ = ~1,
  e_fn = "survLm",
  l_fn = NULL,
  bin_size = NULL,
  gridpts = 3,
  perm_reps = 1000L,
  pval = 0.05
)
```

Arguments

`rp_equ` formula containing all variables for partitioning

`data` data.frame that includes variables used in rp_equ, e_equ, and design information

`weights` formula or vector of sample weights for each observation

`strata` formula or vector of strata labels

`clusters` formula or vector of cluster labels

`e_equ` formula for modeling data in each node

`e_fn` string name of function to use for modeling (only "survLm" is operational)

`l_fn` loss function (ignored)

`bin_size` integer specifying minimum number of observations in each node

`gridpts` integer number of middle points to do in search; set to n for categorical variables when e_equ is used.

`perm_reps` integer specifying the number of thousands of permutation replications to use to estimate p-value

`pval` numeric p-value used to reject null hypothesis in permutation test

Value

object of class "rpms"

Examples

```
{
# model mean of retirement account value for households with reported
# retirment account values > 0 using a binary tree while accounting for
# clusterd data and sample weights.

s1<- which(CE$IRAX > 0)
rpms(IRAX~EDUCA+AGE+BLS_URBN, data=CE[s1,], weights=~FINLWT21, clusters=~CID)


# model linear fit between retirement account value and amount of income
# conditioning on education and accounting for clusterd data for households
# with reported retirment account values > 0

rpms(IRAX~EDUCA, e_equ=IRAX~FINCBTAX, data=CE[s1,], weights=~FINLWT21, clusters=~CID)

}
```

`rpms_boost` *rpms_boost*

Description

function for producing boosted rpms models (trees or random forests)

Usage

```
rpms_boost(
  rp_equ,
  data,
  weights = ~1,
  strata = ~1,
  clusters = ~1,
  e_equ = ~1,
  bin_size = NULL,
  gridpts = 3,
  perm_reps = 100L,
  pval = 0.05,
  f_size = 200L,
  model_type = "tree",
  times = 2L
)
```

Arguments

`rp_equ` formula containing all variables for partitioning

`data` data.frame that includes variables used in rp_equ, e_equ, and design information

`weights` formula or vector of sample weights for each observation

`strata` formula or vector of strata labels

`clusters` formula or vector of cluster labels

`e_equ` formula for modeling data in each node

`bin_size` numeric minimum number of observations in each node

`gridpts` integer number of middle points to do in search

`perm_reps` integer specifying the number of thousands of permuation replications to use to estimate p-value

`pval` numeric p-value used to reject null hypothesis in permutation test

`f_size` integer specifying the number of trees in the forest (only used if model_type is "forest")

`model_type` string: one of "tree" or "forest"

`times` integer specifying number of boosting levels to try.

Value

object of class "rpms_boost"

Examples

```
{
# model mean of retirement contributions with a binary tree while accounting
# for clusterd data and sample weights.

rpms_boost(IRAX~EDUCA+AGE+BLS_URBN, data = CE,  weights=~FINLWT21, clusters=~CID, pval=.01)


}
```

`rpms_forest` *rpms_forest*

Description

produces a random forest using rpms to create the individual trees.

Usage

```
rpms_forest(
  rp_equ,
  data,
  weights = ~1,
  strata = ~1,
  clusters = ~1,
  e_fn = "survLm",
  l_fn = NULL,
  bin_size = 5,
  f_size = 500,
  cores = 1
)
```

Arguments

`rp_equ` formula containing all variables for partitioning

`data` data.frame that includes variables used in rp_equ, e_equ, and design information

`weights` formula or vector of sample weights for each observation

`strata` formula or vector of strata labels

`clusters` formula or vector of cluster labels

`e_fn` string name of function to use for modeling (only "survLm" is operational)

`l_fn` loss function (ignored)

`bin_size` numeric minimum number of observations in each node

`f_size` integer specifying the number of trees in the forest

`cores` integer number of cores to use in parallel if > 1 (doesn't work with Windows operating systems)

Value

object of class "rpms"

`rpms_proj` *rpms_proj*

Description

Returns a survLm_fit object with coeficients projecting new data onto splits from the given rpms model.

Usage

```
rpms_proj(object, newdata, weights = ~1, strata = ~1, clusters = ~1)
```

Arguments

object Object inheriting from rpms

newdata data frame with variables used to estimate model

weights formula or vector of sample weights for each observation

strata formula or vector of strata labels

clusters formula or vector of cluster labels

Value

survLm_fit object

rpms_zinf *rpms_zinf*

Description

main function producing a regression tree using variables from rp_equ to partition the data and fit the model e_equ on each node. Currently only uses data with complete cases.

Usage

```
rpms_zinf(
  rp_equ,
  data,
  weights = ~1,
  strata = ~1,
  clusters = ~1,
  e_equ = ~1,
  e_fn = "survLm",
  l_fn = NULL,
  bin_size = NULL,
  gridpts = 3,
  perm_reps = 1000L,
  pval = 0.05
)
```

Arguments

rp_equ formula containing all variables for partitioning

data data.frame that includes variables used in rp_equ, e_equ, and design information

weights formula or vector of sample weights for each observation

strata formula or vector of strata labels

clusters formula or vector of cluster labels

e_equ formula for modeling data in each node `e_fn` string name of function to use for modeling (only "survLm" is operational)

`l_fn` loss function (does nothing yet)

`bin_size` numeric minimum number of observations in each node

`gridpts` integer number of middle points to do in search

`perm_reps` integer specifying the number of thousands of permuation replications to use to estimate p-value

`pval` numeric p-value used to reject null hypothesis in permutation test

Value

object of class "rpms"

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