

Package ‘FFTrees’

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Type Package

Title Generate, Visualise, and Evaluate Fast-and-Frugal Decision Trees

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Description Create, visualize, and test fast-and-frugal decision trees (FFTs). FFTs are very simple decision trees for binary classification problems. FFTs can be preferable to more complex algorithms because they are easy to communicate, require very little information, and are robust against overfitting.

LazyData TRUE

Depends R(>= 2.10)

Imports rpart, yarr, circlize, parallel, graphics, randomForest, igrph, e1071, stringr, progress, pROC, caret

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BugReports <https://github.com/ndphillips/FFTrees/issues>

RoxygenNote 6.0.1

Suggests knitr, rmarkdown

VignetteBuilder knitr

NeedsCompilation no

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R topics documented:

Add_Stats	3
apply.tree	3
blood	4
breastcancer	5
car	5
classtable	6
comp.pred	7
contraceptive	7
creditapproval	8
cuerank	9
factclean	10
fan.algorithm	10
fertility	12
FFForest	12
FFTrees	14
FFTrees.guide	17
forestfires	17
grow.FFTrees	18
heart.cost	20
heart.fff	21
heart.test	21
heart.train	22
heartdisease	23
heuristic.algorithm	24
inwords	24
iris.v	25
mushrooms	26
plot.FFForest	27
plot.FFTrees	27
predict.FFForest	29
predict.FFTrees	29
print.FFForest	30
print.FFTrees	31
showcues	31
sonar	32
summary.FFTrees	32
threshold_factor_grid	33
threshold_numeric_grid	33
titanic	34
updateHistory	35
voting	35
wine	36
wordstoFFT	36

Add_Stats

Adds decision statistics to a dataframe containing hr, cr, mi and fa

Description

Adds decision statistics to a dataframe containing hr, cr, mi and fa

Usage

```
Add_Stats(data, sens.w = 0.5, cost.each = NULL, cost.outcomes = list(hi =
  0, fa = 1, mi = 1, cr = 0))
```

Arguments

data	dataframe. With named (integer) columns hi, cr, mi, fa
sens.w	numeric. Sensitivity weight
cost.each	numeric. An optional fixed cost added to all outputs (e.g.; the cost of the cue)
cost.outcomes	list. A list of length 4 with names 'hi', 'fa', 'mi', and 'cr' specifying the costs of a hit, false alarm, miss, and correct rejection respectively. E.g.; <code>cost.outcomes = listc("hi" = 0, "fa"</code> means that a false alarm and miss cost 10 and 20 respectively while correct decisions have no cost.

apply.tree

Applies a fast-and-frugal tree to a dataset and generates several accuracy statistics

Description

Applies a fast-and-frugal tree to a dataset and generates several accuracy statistics

Usage

```
apply.tree(data, formula, tree.definitions, sens.w = 0.5,
  cost.outcomes = list(hi = 0, fa = 1, mi = 1, cr = 0), cost.cues = NULL,
  allNA.pred = FALSE)
```

Arguments

data	dataframe. A model training dataset. An m x n dataframe containing n cue values for each of the m exemplars.
formula	A formula
tree.definitions	dataframe. Definitions of one or more trees. The dataframe must contain the columns: cues, classes, thresholds, directions, exits.

<code>sens.w</code>	numeric. A number from 0 to 1 indicating how to weight sensitivity relative to specificity. Only used for calculating wacc values.
<code>cost.outcomes</code>	list. A list of length 4 with names 'hi', 'fa', 'mi', and 'cr' specifying the costs of a hit, false alarm, miss, and correct rejection respectively. E.g.; <code>cost.outcomes = listc("hi" = 0, "fa"</code> means that a false alarm and miss cost 10 and 20 respectively while correct decisions have no cost.
<code>cost.cues</code>	dataframe. A dataframe with two columns specifying the cost of each cue. The first column should be a vector of cue names, and the second column should be a numeric vector of costs. Cues in the dataset not present in <code>cost.cues</code> are assume to have 0 cost.
<code>allNA.pred</code>	logical. What should be predicted if all cue values in tree are NA? Default is FALSE

Value

A list of length 4 containing

blood	<i>Blood donation dataset</i>
-------	-------------------------------

Description

Blood donation dataset

Usage

blood

Format

A data frame containing 748 rows and 5 columns

recency Months since last donation

frequency Total number of donations

total Total blood donated in c.c.

time Months since first donation

donation.crit Did he/she donated blood in March 2007? ...

Source

<https://archive.ics.uci.edu/ml/datasets/Blood+Transfusion+Service+Center>

breastcancer	<i>Dataset: Physiological dataset for 699 patients tested for breast cancer.</i>
--------------	--

Description

Dataset: Physiological dataset for 699 patients tested for breast cancer.

Usage

breastcancer

Format

A data frame containing 699 rows and 9 columns

thickness Clump Thickness

cellsize.unif Uniformity of Cell Size

cellshape.unif Uniformity of Cell Shape

adhesion Marginal Adhesion

epithelial Single Epithelial Cell Size

nuclei.bare Bare Nuclei

chromatin Bland Chromatin

nucleoli Normal Nucleoli

mitoses Mitoses

diagnosis Is cancer present? T or F

...

Source

[https://archive.ics.uci.edu/ml/datasets/Breast+Cancer+Wisconsin+\(Original\)](https://archive.ics.uci.edu/ml/datasets/Breast+Cancer+Wisconsin+(Original))

car	<i>Car acceptability data</i>
-----	-------------------------------

Description

Car acceptability data

Usage

car

Format

A data frame containing 1728 rows and 7 columns

buying.price Numeric

maint.price Factor

doors Factor

persons Numeric

luggage Numeric

safety Factor

acceptability Factor

...

Source

<http://archive.ics.uci.edu/ml/datasets/Car+Evaluation>

classtable	<i>Calculates several classification statistics from binary prediction and criterion (e.g.; truth) vectors</i>
------------	--

Description

Calculates several classification statistics from binary prediction and criterion (e.g.; truth) vectors

Usage

```
classtable(prediction.v = NULL, criterion.v, sens.w = 0.5, cost.v = NULL,
           correction = 0.25, cost.outcomes = list(hi = 0, fa = 1, mi = 1, cr = 0))
```

Arguments

prediction.v logical. A logical vector of predictions

criterion.v logical A logical vector of criterion (true) values

sens.w numeric. Weight given to sensitivity, must range from 0 to 1.

cost.v list. An optional list of additional costs to be added to each case.

correction numeric. Correction added to all counts for calculating dprime

cost.outcomes list. A list of length 4 with names 'hi', 'fa', 'mi', and 'cr' specifying the costs of a hit, false alarm, miss, and correct rejection respectively. E.g.; `cost.outcomes = listc("hi" = 0, "fa" = 10, "mi" = 20, "cr" = 0)` means that a false alarm and miss cost 10 and 20 respectively while correct decisions have no cost.

comp.pred	<i>Wrapper for classification algorithms</i>
-----------	--

Description

This function is a wrapper for many classification algorithms such as CART (rpart::rpart), logistic regression (glm), support vector machines (svm::svm) and random forests (randomForest::randomForest)

Usage

```
comp.pred(formula, data.train, data.test = NULL, algorithm = NULL,
          model = NULL, new.factors = "exclude")
```

Arguments

formula	a formula
data.train	dataframe. A training dataset
data.test	dataframe. A testing dataset
algorithm	string. An algorithm in the set "lr" – logistic regression, "cart" – decision trees, "rlr" – regularised logistic regression, "svm" – support vector machines, "rf" – random forests
model	model. An optional existing model applied to test data
new.factors	string. What should be done if new factor values are discovered in the test set? "exclude" = exclude (i.e.; remove these cases), "base" = predict the base rate of the criterion.

contraceptive	<i>Contraceptive use data</i>
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Description

Contraceptive use data

Usage

```
contraceptive
```

Format

A data frame containing 1473 rows and 10 columns

wife.age Numeric

wife.edu Factor

hus.ed Factor

children Numeric

wife.rel Numeric

wife.work Factor

hus.occ Factor

sol Factor

media Numeric

cont.crit numeric

...

Source

<https://archive.ics.uci.edu/ml/datasets/Contraceptive+Method+Choice>

creditapproval

Credit approval data

Description

Credit approval data

Usage

creditapproval

Format

A data frame containing 690 rows and 15 columns

Source

<https://archive.ics.uci.edu/ml/datasets/Credit+Approval>

cuerank	<i>Calculates thresholds that maximize a statistic (goal) for cues.</i>
---------	---

Description

Calculates thresholds that maximize a statistic (goal) for cues.

Usage

```
cuerank(formula = NULL, data = NULL, goal.threshold = "bacc",
        sens.w = 0.5, cost.outcomes = list(hi = 0, fa = 1, mi = 1, cr = 0),
        cost.cues = NULL, numthresh.method = "o", numthresh.n = 20,
        rounding = NULL, cue.rules = NULL, quiet = FALSE)
```

Arguments

formula	formula. A formula specifying a binary criterion as a function of multiple variables
data	dataframe. A dataframe containing variables in formula
goal.threshold	character. A string indicating the statistic to maximize when calculating cue thresholds: "acc" = overall accuracy, "wacc" = weighted accuracy, "bacc" = balanced accuracy
sens.w	numeric. A number from 0 to 1 indicating how to weight sensitivity relative to specificity.
cost.outcomes	list. A list of length 4 with names 'hi', 'fa', 'mi', and 'cr' specifying the costs of a hit, false alarm, miss, and correct rejection respectively. E.g.; <code>cost.outcomes = listc("hi" = 0, "fa"</code> means that a false alarm and miss cost 10 and 20 respectively while correct decisions have no cost.
cost.cues	dataframe. A dataframe with two columns specifying the cost of each cue. The first column should be a vector of cue names, and the second column should be a numeric vector of costs. Cues in the dataset not present in <code>cost.cues</code> are assume to have 0 cost.
numthresh.method	character. A string indicating how to calculate cue splitting thresholds. "m" = median split, "o" = split that maximizes the goal,
numthresh.n	integer. The maximum number of numeric thresholds to be considered.
rounding	integer. An integer indicating digit rounding for non-integer numeric cue thresholds. The default is NULL which means no rounding. A value of 0 rounds all possible thresholds to the nearest integer, 1 rounds to the nearest .1 (etc.).
cue.rules	dataframe. Optional existing dataframe of previously defined cue rules.
quiet	logical. Should ongoing diagnostics be printed?

Value

A dataframe containing thresholds and marginal classification statistics for each cue

Examples

```
## Not run:
# What are the best thresholds for each cue in the mushrooms dataset?
mushrooms.cues <- cuerank(formula = poisonous ~.,
                          data = mushrooms)

## End(Not run)
```

factclean

Does miscellaneous cleaning of prediction datasets

Description

Does miscellaneous cleaning of prediction datasets

Usage

```
factclean(data.train, data.test, show.warning = T)
```

Arguments

```
data.train    A training dataset
data.test     A testing dataset
show.warning  ...
```

fan.algorithm

Grows fast-and-frugal trees using the fan algorithm

Description

Grows fast-and-frugal trees using the fan algorithm

Usage

```
fan.algorithm(formula, data, max.levels = 5, algorithm = "ifan",
              goal = "wacc", goal.chase = "bacc", goal.threshold = "bacc",
              sens.w = 0.5, cost.outcomes = list(hi = 0, fa = 1, mi = 1, cr = 0),
              cost.cues = NULL, numthresh.method = "o", numthresh.n = 20,
              stopping.rule = "exemplars", stopping.par = 0.1, rounding = NULL,
              quiet = TRUE, repeat.cues = TRUE)
```

Arguments

formula	formula. A formula
data	dataframe. A dataset
max.levels	integer. The maximum number of levels in the tree(s)
algorithm	character. A string indicating how to rank cues during tree construction. "ifan" (independent fan) means that cues will only be ranked once with the entire training dataset "dfan" (dependent fan) means that cues will be ranked after each level in the tree with the remaining unclassified training exemplars.
goal	character. A string indicating the statistic to maximize: "acc" = overall accuracy, "bacc" = balanced accuracy, "wacc" = weighted accuracy, "bacc" = balanced accuracy
goal.chase	character. A string indicating the statistic to maximize when constructing trees: "acc" = overall accuracy, "wacc" = weighted accuracy, "bacc" = balanced accuracy
goal.threshold	character. A string indicating the statistic to maximize when calculating cue thresholds: "acc" = overall accuracy, "wacc" = weighted accuracy, "bacc" = balanced accuracy
sens.w	numeric. A number from 0 to 1 indicating how to weight sensitivity relative to specificity.
cost.outcomes	list. A list of length 4 with names 'hi', 'fa', 'mi', and 'cr' specifying the costs of a hit, false alarm, miss, and correct rejection respectively. E.g.; cost.outcomes = listc("hi" = 0, "fa"
cost.cues	dataframe. A dataframe with two columns specifying the cost of each cue. The first column should be a vector of cue names, and the second column should be a numeric vector of costs. Cues in the dataset not present in cost.cues are assume to have 0 cost.
numthresh.method	character. How should thresholds for numeric cues be determined? "o" will optimize thresholds, while "m" will always use the median.
numthresh.n	numeric. Number of threshold values to consider.
stopping.rule	character. A string indicating the method to stop growing trees. "levels" means the tree grows until a certain level, "exemplars" means the tree grows until a certain number of unclassified exemplars remain. "statdelta" means the tree grows until the change in the criterion statistic is less than a specified level.
stopping.par	numeric. A number indicating the parameter for the stopping rule. For stopping.rule == "levels", this is the number of levels. For stopping rule "exemplars", this is the smallest percentage of exemplars allowed in the last level.
rounding	integer. How much should threshold parameters be rounded? Default is
quiet	logical. Should tree growing progress be displayed?
repeat.cues	logical. Can cues occur multiple times within a tree?
...	Currently ignored

Value

A definition of an FFT

fertility	<i>Fertility data set</i>
-----------	---------------------------

Description

Fertility data set

Usage

```
fertility
```

Format

A data frame containing 100 rows and 10 columns

Source

<https://archive.ics.uci.edu/ml/datasets/Fertility>

FFForest	<i>Creates a forest of fast and frugal decision trees</i>
----------	---

Description

This function is currently in development. The idea is to generate a random forest of fast and frugal trees from many splits of the training dataset.

Usage

```
FFForest(formula = NULL, data = NULL, data.test = NULL, max.levels = 5,
  ntree = 10, train.p = 0.5, algorithm = "ifan", goal = "wacc",
  goal.chase = "wacc", sens.w = 0.5, quiet = TRUE, cpus = 1,
  do.comp = FALSE, do.lr = TRUE, do.cart = TRUE, do.rf = TRUE,
  do.svm = TRUE, rank.method = NULL, hr.weight = NULL)
```

Arguments

formula	formula. A formula specifying a binary criterion as a function of multiple variables
data	dataframe. A dataframe containing variables in formula
data.test	dataframe. An optional dataframe of test data
max.levels	integer. Maximum number of levels considered for the trees.
ntree	integer. Number of trees to create.
train.p	numeric. What percentage of the data should be used to fit each tree? Smaller values will result in more diverse trees.
algorithm	string. The algorithm uses to create FFTs. See arguments in FFTrees()
goal	character. A string indicating the statistic to maximize when selecting final trees: "acc" = overall accuracy, "bacc" = balanced accuracy, "d" = d-prime
goal.chase	character. A string indicating the statistic to maximize when constructing trees: "acc" = overall accuracy, "wacc" = weighted accuracy, "bacc" = balanced accuracy
sens.w	numeric. How much weight to give to maximizing hits versus minimizing false alarms (between 0 and 1)
quiet	logical. Should progress reports be printed?
cpus	integer. Number of cpus to use. Any value larger than 1 will initiate parallel calculations in snowfall.
do.comp, do.lr, do.cart, do.rf, do.svm	logical. See arguments in FFTrees()
rank.method, hr.weight	deprecated arguments

Value

An object of class FFForest with the following elements...

Examples

```
## Not run:
cancer.fff <- FFForest(formula = diagnosis ~.,
                      data = breastcancer,
                      ntree = 10,
                      train.p = .5,
                      cpus = 1)

## End(Not run)
```

 FFTrees

Creates a fast-and-frugal trees (FFTrees) object.

Description

This is the workhorse function for the FFTrees package. It creates (one or more) fast-and-frugal decision trees trained on a training dataset and tested on an optional test dataset.

Usage

```
FFTrees(formula = NULL, data = NULL, data.test = NULL,
        algorithm = "ifan", max.levels = NULL, sens.w = 0.5,
        cost.outcomes = NULL, cost.cues = NULL, stopping.rule = "exemplars",
        stopping.par = 0.1, goal = NULL, goal.chase = NULL,
        goal.threshold = "bacc", numthresh.method = "o",
        decision.labels = c("False", "True"), main = NULL, train.p = 1,
        rounding = NULL, repeat.cues = TRUE, my.tree = NULL,
        tree.definitions = NULL, do.comp = TRUE, do.cart = TRUE, do.lr = TRUE,
        do.rf = TRUE, do.svm = TRUE, store.data = FALSE, object = NULL,
        rank.method = NULL, force = FALSE, verbose = NULL, comp = NULL,
        quiet = TRUE)
```

Arguments

formula	formula. A formula specifying a logical criterion as a function of 1 or more predictors.
data	dataframe. A training dataset.
data.test	dataframe. An optional testing dataset with the same structure as data.
algorithm	character. The algorithm to create FFTs. Can be 'ifan', 'dfan', 'max', or 'zigzag'.
max.levels	integer. The maximum number of levels considered for the trees. Because all permutations of exit structures are considered, the larger max.levels is, the more trees will be created.
sens.w	numeric. A number from 0 to 1 indicating how to weight sensitivity relative to specificity. Only relevant when goal = 'wacc'
cost.outcomes	list. A list of length 4 with names 'hi', 'fa', 'mi', and 'cr' specifying the costs of a hit, false alarm, miss, and correct rejection respectively. E.g.; cost.outcomes = listc("hi" = 0, "fa"
cost.cues	list A list containing containing costs for each cue. Each element should have a name corresponding to a column in data, and each entry should be a single (positive) number. Cues not present in cost.cues are assume to have 0 cost.
stopping.rule	character. A string indicating the method to stop growing trees. "levels" means the tree grows until a certain level. "exemplars" means the tree grows until a certain number of unclassified exemplars remain. "statdelta" means the tree grows until the change in the criterion statistic is less than a specified level.

<code>stopping.par</code>	numeric. A number indicating the parameter for the stopping rule. For <code>stopping.rule == "levels"</code> , this is the number of levels. For <code>stopping.rule == "exemplars"</code> , this is the smallest percentage of exemplars allowed in the last level.
<code>goal</code>	character. A string indicating the statistic to maximize when selecting final trees: "acc" = overall accuracy, "wacc" = weighted accuracy, "bacc" = balanced accuracy
<code>goal.chase</code>	character. A string indicating the statistic to maximize when constructing trees: "acc" = overall accuracy, "wacc" = weighted accuracy, "bacc" = balanced accuracy, "cost" = cost.
<code>goal.threshold</code>	character. A string indicating the statistic to maximize when calculating cue thresholds: "acc" = overall accuracy, "wacc" = weighted accuracy, "bacc" = balanced accuracy
<code>numthresh.method</code>	character. How should thresholds for numeric cues be determined? "o" will optimize thresholds, while "m" will always use the median.
<code>decision.labels</code>	string. A vector of strings of length 2 indicating labels for negative and positive cases. E.g.; <code>decision.labels = c("Healthy", "Diseased")</code>
<code>main</code>	string. An optional label for the dataset. Passed on to other functions like <code>plot.FFTrees()</code> , and <code>print.FFTrees()</code>
<code>train.p</code>	numeric. What percentage of the data to use for training when <code>data.test</code> is not specified? For example, <code>train.p = .5</code> will randomly split data into a 50% training set and a 50% test set. <code>train.p = 1</code> , the default, uses all data for training.
<code>rounding</code>	integer. An integer indicating digit rounding for non-integer numeric cue thresholds. The default is NULL which means no rounding. A value of 0 rounds all possible thresholds to the nearest integer, 1 rounds to the nearest .1 (etc.).
<code>repeat.cues</code>	logical. Can cues occur multiple times within a tree?
<code>my.tree</code>	string. A string representing an FFT in words. For example, <code>my.tree = "If age > 20, predict TRUE."</code>
<code>tree.definitions</code>	dataframe. An optional hard-coded definition of trees (see details below). If specified, no new trees are created.
<code>do.comp, do.cart, do.lr, do.rf, do.svm</code>	logical. Should alternative algorithms be created for comparison? <code>cart</code> = regular (non-frugal) trees with <code>rpart</code> , <code>lr</code> = logistic regression with <code>glm</code> , <code>rf</code> = random forests with <code>randomForest</code> , <code>svm</code> = support vector machines with <code>e1071</code> . Setting <code>comp = FALSE</code> sets all these arguments to FALSE.
<code>store.data</code>	logical. Should training / test data be stored in the object? Default is FALSE.
<code>object</code>	FFTrees. An optional existing FFTrees object. When specified, no new trees are fitted and the existing trees are applied to <code>data</code> and <code>data.test</code> .
<code>rank.method, verbose, comp</code>	deprecated arguments.
<code>force</code>	logical. If TRUE, forces some parameters (like <code>goal</code>) to be as specified by the user even when the algorithm thinks those specifications don't make sense.
<code>quiet</code>	logical. Should progress reports be printed? Can be helpful for diagnosis when the function is running slowly.

Value

An FFTrees object with the following elements

formula The formula specified when creating the FFTs.

data.desc Descriptive statistics of the data

cue.accuracy Marginal accuracies of each cue given a decision threshold calculated with the specified algorithm

tree.definitions Definitions of each tree created by FFTrees. Each row corresponds to one tree. Different levels within a tree are separated by semi-colons. See above for more details.

tree.stats Tree definitions and classification statistics. Training and test data are stored separately

cost A list of cost information for each case in each tree.

level.stats Cumulative classification statistics at each tree level. Training and test data are stored separately

decision Final classification decisions. Each row is a case and each column is a tree. For example, row 1 in column 2 is the classification decision of tree number 2 for the first case. Training and test data are stored separately.

levelout The level at which each case is classified in each tree. Rows correspond to cases and columns correspond to trees. Training and test data are stored separately.

tree.max The index of the 'final' tree specified by the algorithm. For algorithms that only return a single tree, this value is always 1.

inwords A verbal definition of tree.max.

params A list of defined control parameters (e.g.; algorithm, goal)

comp Models and classification statistics for competitive classification algorithms: Regularized logistic regression, CART, and random forest.

data The original training and test data (only included when store.data = TRUE)

Examples

```
# Create fast-and-frugal trees for heart disease
heart.fft <- FFTrees(formula = diagnosis ~.,
                    data = heart.train,
                    data.test = heart.test,
                    main = "Heart Disease",
                    decision.labels = c("Healthy", "Diseased"))

# Print the result for summary info
heart.fft

# Plot the tree applied to training data
plot(heart.fft, stats = FALSE)
plot(heart.fft)
plot(heart.fft, data = "test") # Now for testing data
plot(heart.fft, data = "test", tree = 2) # Look at tree number 2
```



```
## Predict classes and probabilities for new data

predict(heart.fft, newdata = heartdisease)
predict(heart.fft, newdata = heartdisease, type = "prob")

### Create your own custom tree with my.tree

custom.fft <- FFTrees(formula = diagnosis ~ .,
                      data = heartdisease,
                      my.tree = 'If chol > 300, predict True.
                                If sex = {m}, predict False,
                                If age > 70, predict True, otherwise predict False'
                      )

# Plot the custom tree (it's pretty terrible)
plot(custom.fft)
```

FFTrees.guide

Opens the FFTrees package guide

Description

Opens the FFTrees package guide

Usage

```
FFTrees.guide()
```

forestfires

forestfires

Description

A dataset of forest fire statistics.

Usage

```
forestfires
```

Format

A data frame containing 517 rows and 13 columns

X Integer -x-axis spatial coordinate within the Montesinho park map: 1 to 9

Y Integer - y-axis spatial coordinate within the Montesinho park map: 2 to 9

month Factor - month of the year: "jan" to "dec"

day Factor -day of the week: "mon" to "sun"

FFMC Numeric -FFMC index from the FWI system: 18.7 to 96.20

DMC Numeric - DMC index from the FWI system: 1.1 to 291.3

DC Numeric - DC index from the FWI system: 7.9 to 860.6

ISI Numeric - ISI index from the FWI system: 0.0 to 56.10

temp Numeric - temperature in Celsius degrees: 2.2 to 33.30

RH Numeric - relative humidity in percent: 15.0 to 100

wind Numeric - wind speed in km/h: 0.40 to 9.40

rain Numeric - outside rain in mm/m2 : 0.0 to 6.4

area Numeric - the burned area of the forest (in ha): 0.00 to 1090.84

...

Source

<http://archive.ics.uci.edu/ml/datasets/Forest+Fires>

grow.FFTrees	<i>Grows fast-and-frugal trees using an algorithm specified by algorithm.</i>
--------------	---

Description

Grows fast-and-frugal trees using an algorithm specified by `algorithm`.

Usage

```
grow.FFTrees(formula, data, max.levels = NULL, algorithm = "ifan",
  goal = "wacc", goal.chase = "bacc", goal.threshold = "bacc",
  sens.w = 0.5, cost.outcomes = list(hi = 0, fa = 1, mi = 1, cr = 0),
  cost.cues = NULL, numthresh.method = "o", stopping.rule = "exemplars",
  stopping.par = 0.1, quiet = FALSE, repeat.cues = TRUE,
  rank.method = NULL, cue accuracies = NULL, ...)
```

Arguments

<code>formula</code>	formula. A formula
<code>data</code>	dataframe. A dataset
<code>max.levels</code>	integer. The maximum number of levels in the tree(s)
<code>algorithm</code>	character. A string indicating how to rank cues during tree construction. "m" (for ifan) means that cues will only be ranked once with the entire training dataset. "c" (conditional) means that cues will be ranked after each level in the tree with the remaining unclassified training exemplars.
<code>goal</code>	character. A string indicating the statistic to maximize: "acc" = overall accuracy, "bacc" = balanced accuracy, "wacc" = weighted accuracy
<code>goal.chase</code>	character. A string indicating the statistic to maximize when constructing trees: "acc" = overall accuracy, "wacc" = weighted accuracy, "bacc" = balanced accuracy
<code>goal.threshold</code>	character. A string indicating the statistic to maximize when calculating cue thresholds: "acc" = overall accuracy, "wacc" = weighted accuracy, "bacc" = balanced accuracy
<code>sens.w</code>	numeric. A number from 0 to 1 indicating how to weight sensitivity relative to specificity.
<code>cost.outcomes</code>	numeric. A vector of length 4 specifying the costs of a hit, false alarm, miss, and correct rejection respectively. E.g.; <code>cost.outcomes = c(0, 10, 20, 0)</code> means that a false alarm and miss cost 10 and 20 respectively while correct decisions have no cost.
<code>cost.cues</code>	dataframe. A dataframe with two columns specifying the cost of each cue. The first column should be a vector of cue names, and the second column should be a numeric vector of costs. Cues in the dataset not present in <code>cost.cues</code> are assumed to have 0 cost.
<code>numthresh.method</code>	character. How should thresholds for numeric cues be determined? "o" will optimize thresholds, while "m" will always use the median.
<code>stopping.rule</code>	character. A string indicating the method to stop growing trees. "levels" means the tree grows until a certain level. "exemplars" means the tree grows until a certain number of unclassified exemplars remain. "statdelta" means the tree grows until the change in the criterion statistic is less than a specified level.
<code>stopping.par</code>	numeric. A number indicating the parameter for the stopping rule. For <code>stopping.rule == "levels"</code> , this is the number of levels. For <code>stopping.rule == "exemplars"</code> , this is the smallest percentage of exemplars allowed in the last level.
<code>quiet</code>	logical. Should progress messages be shown?
<code>repeat.cues</code>	logical. Can cues occur multiple times within a tree?
<code>rank.method</code>	deprecated arguments
<code>cue accuracies</code>	deprecated arguments
<code>...</code>	Currently ignored

Value

A list of length 4. `tree.definitions` contains definitions of the tree(s). `tree.stats` contains classification statistics for the tree(s). `levelout` shows which level in the tree(s) each exemplar is classified. Finally, `decision` shows the classification decision for each tree for each exemplar

Examples

```
titanic.trees <- grow.FFTrees(formula = survived ~.,
                             data = titanic)

# Tree definitions are stored in tree.definitions
titanic.trees$tree.definitions

# Tree classification statistics are in tree.stats
titanic.trees$tree.stats

# The level at which each exemplar is classified for each tree is in levelout
titanic.trees$levelout

# The decision for each exemplar for each tree is in decision
titanic.trees$decision
```

`heart.cost`*Cue costs for the heartdisease dataa*

Description

Cue costs for the heartdisease dataa

Usage

```
heart.cost
```

Format

A data frame containing 153 rows and 14 columns

cue The name of the cue

cost The cost of the cue

...

Source

<https://archive.ics.uci.edu/ml/machine-learning-databases/heart-disease/costs/>

heart.fff

An FFForest object trained on the heartdisease dataset.

Description

An FFForest object trained on the heartdisease dataset.

Usage

```
heart.fff
```

Format

An FFForest object

Details

The code used to generate this object was `heart.fff <- FFForest(diagnosis ~., data = heartdisease, ntree = 100`

heart.test

Heartdisease testing dataset

Description

Testing data for a heart disease dataset. These data are used to test the prediction performance of a model trained on the heart.train data. The dataset heartdisease contains both datasets.

Usage

```
heart.test
```

Format

A data frame containing 153 rows and 14 columns

age Age

sex Sex, 1 = male, 0 = female

cp Chest pain type: ta = typical angina, aa = atypical angina, np = non-anginal pain, a = asymptomatic

trestbps Resting blood pressure (in mm Hg on admission to the hospital)

chol Serum cholestorl in mg/dl

fbs Fasting blood sugar > 120 mg/dl: 1 = true, 0 = false

restecg Resting electrocardiographic results. "normal" = normal, "abnormal" = having ST-T wave abnormality (T wave inversions and/or ST elevation or depression of > 0.05 mV), "hypertrophy" = showing probable or definite left ventricular hypertrophy by Estes' criteria.

thalach Maximum heart rate achieved

exang Exercise induced angina: 1 = yes, 0 = no

oldpeak ST depression induced by exercise relative to rest

slope The slope of the peak exercise ST segment.

ca Number of major vessels (0-3) colored by flourosopy

thal "normal" = normal, "fd" = fixed defect, "rd" = reversable defect

diagnosis 1 = Heart disease, 0 = No Heart disease

...

Source

<https://archive.ics.uci.edu/ml/datasets/Heart+Disease>

heart.train	<i>Heartdisease training dataset.</i>
-------------	---------------------------------------

Description

Training data for a heart disease dataset used to train a model. The corresponding dataset for model testing is heart.test. The dataset heartdisease contains both datasets.

Usage

heart.train

Format

A data frame containing 150 rows and 14 columns

age Age

sex Sex, 1 = male, 0 = female

cp Chest pain type: ta = typical angina, aa = atypical angina, np = non-anginal pain, a = asymptomatic

trestbps Resting blood pressure (in mm Hg on admission to the hospital)

chol Serum cholestoral in mg/dl

fbs Fasting blood sugar > 120 mg/dl: 1 = true, 0 = false

restecg Resting electrocardiographic results. "normal" = normal, "abnormal" = having ST-T wave abnormality (T wave inversions and/or ST elevation or depression of > 0.05 mV), "hypertrophy" = showing probable or definite left ventricular hypertrophy by Estes' criteria.

thalach Maximum heart rate achieved
exang Exercise induced angina: 1 = yes, 0 = no
oldpeak ST depression induced by exercise relative to rest
slope The slope of the peak exercise ST segment.
ca Number of major vessels (0-3) colored by flourosopy
thal "normal" = normal, "fd" = fixed defect, "rd" = reversable defect
diagnosis 1 = Heart disease, 0 = No Heart disease
 ...

Source

<https://archive.ics.uci.edu/ml/datasets/Heart+Disease>

heartdisease	<i>Heart disease dataset</i>
--------------	------------------------------

Description

Data for 303 patients tested for heart disease

Usage

heartdisease

Format

A data frame containing 303 rows and 14 columns

age Age
sex Sex, 1 = male, 0 = female
cp Chest pain type: ta = typical angina, aa = atypical angina, np = non-anginal pain, a = asymptomatic
trestbps Resting blood pressure (in mm Hg on admission to the hospital)
chol Serum cholestoral in mg/dl
fbs Fasting blood sugar > 120 mg/dl: 1 = true, 0 = false
restecg Resting electrocardiographic results. "normal" = normal, "abnormal" = having ST-T wave abnormality (T wave inversions and/or ST elevation or depression of > 0.05 mV), "hypertrophy" = showing probable or definite left ventricular hypertrophy by Estes' criteria.
thalach Maximum heart rate achieved
exang Exercise induced angina: 1 = yes, 0 = no
oldpeak ST depression induced by exercise relative to rest
slope The slope of the peak exercise ST segment.
ca Number of major vessels (0-3) colored by flourosopy
thal "normal" = normal, "fd" = fixed defect, "rd" = reversable defect
diagnosis 1 = Heart disease, 0 = No Heart disease
 ...

Source

<https://archive.ics.uci.edu/ml/datasets/Heart+Disease>

heuristic.algorithm	<i>Heuristic algorithms for building FFTs originally developed by Martignon, Katsikopoulos & Woike (2008)</i>
---------------------	---

Description

Heuristic algorithms for building FFTs originally developed by Martignon, Katsikopoulos & Woike (2008)

Usage

```
heuristic.algorithm(formula, data, max.levels = NULL, algorithm = "max")
```

Arguments

formula	formula. A formula specifying a logical criterion as a function of 1 or more predictors.
data	dataframe. A training dataset.
max.levels	integer. The maximum number of levels considered for the trees.
algorithm	string. Either 'max' or 'zigzag'

Value

A definition of an FFT

inwords	<i>Describes an FFT in words</i>
---------	----------------------------------

Description

Describes an FFT in words

Usage

```
inwords(x = NULL, tree = NULL, classes.v = NULL, cues.v = NULL,
        directions.v = NULL, thresholds.v = NULL, exits.v = NULL,
        decision.labels = NULL, digits = 2, version = 1)
```


Arguments

x	FFTrees. An FFTrees object created with FFTrees()
tree	integer. An integer specifying which tree in the object to verbalise. The default is x\$tree.max
classes.v	integer.
cues.v	integer.
directions.v	string.
thresholds.v	string.
exits.v	numeric.
decision.labels	string. A string vector (of length 2) indicating labels for negative (0 or FALSE) and positive (1 or TRUE) cases in the criterion
digits	integer. How many digits to round numeric values
version	integer. Which version to show? 1 or 2

Value

A list of string vectors

Examples

```
heart.fft <- FFTrees(diagnosis ~.,
                    data = heartdisease,
                    decision.labels = c("Healthy", "Disease"))

inwords(heart.fft)
```

iris.v

Iris data set

Description

Iris data set

Usage

```
iris.v
```

Format

A data frame containing 150 rows and 4 columns

Source

<https://archive.ics.uci.edu/ml/datasets/Iris>

mushrooms

Mushrooms dataset

Description

Mushrooms dataset

Usage

mushrooms

Format

A data frame containing 8,124 rows and 23 columns (see <http://archive.ics.uci.edu/ml/machine-learning-databases/mushroom/agaricus-lepiota.names> for column descriptions)

poisonous numeric
cshape character
csurface character
ccolor character
bruises character
odor numeric
gattach character
gspace character
gsize character
gcolor character
sshape character
sroot character
ssaring character
ssbring character
scaring character
scbring character
vtype character
vcolor character
ringnum character
ringtype character
sporepc character
population character
habitat character ...

Source

<http://archive.ics.uci.edu/ml/datasets/Mushroom>

plot.FFForest	<i>Creates a network plot.</i>	<i>Code taken from Dirk Wulff (www.dirkwulff.org)</i>
---------------	--------------------------------	---

Description

Creates a network plot. Code taken from Dirk Wulff (www.dirkwulff.org)

Usage

```
## S3 method for class 'FFForest'
plot(x, node.cex.lim = c(1, 10), line.cex.lim = c(0.3,
  5), mincon = 0, lo = "kk", palette = NULL, ...)
```

Arguments

x	FFForest. An FFForest object created from FFForest()
node.cex.lim	numeric. Nodesize adjustment
line.cex.lim	numeric. Edgesize adjustment
mincon	integer. Minimum connection cutoff
lo	string. The layout of the network plot. Either 'kk' (Kamada-Kawai, the default), 'dh' (Davidson-Harel) or 'fr' (Fruchterman-Reingold)
palette	string. A string vector of colors
...	currently ignored

plot.FFTrees	<i>Plots an FFTrees object.</i>
--------------	---------------------------------

Description

Plots an FFTrees object created by the FFTrees() function.

Usage

```
## S3 method for class 'FFTrees'
plot(x = NULL, data = "train", what = "tree",
  tree = "best.train", main = NULL, hlines = TRUE, cue.labels = NULL,
  decision.labels = NULL, cue.cex = NULL, threshold.cex = NULL,
  decision.cex = 1, comp = TRUE, stats = TRUE, show.header = NULL,
  show.tree = NULL, show.confusion = NULL, show.levels = NULL,
  show.roc = NULL, show.icons = NULL, show.iconguide = NULL,
  label.tree = NULL, label.performance = NULL, n.per.icon = NULL,
  which.tree = NULL, level.type = "bar", decision.names = NULL, ...)
```

Arguments

x	A FFTrees object created from "FFTrees()"
data	Either a dataframe of new data, or one of two strings 'train' or 'test'. In this case, the corresponding dataset in the x object will be used.
what	string. What should be plotted? 'tree' (the default) shows one tree (specified by 'tree'). 'cues' shows the marginal accuracy of cues in an ROC space, "roc" shows an roc curve of the tree(s)
tree	integer. An integer indicating which tree to plot (only valid when the tree argument is non-empty). To plot the best training (or test) tree with respect to the goal specified during FFT construction, use "best.train" or "best.test"
main	character. The main plot label.
hlines	logical. Should horizontal panel separation lines be shown?
cue.labels	character. An optional string of labels for the cues / nodes.
decision.labels	character. A string vector of length 2 indicating the content-specific name for noise and signal cases.
cue.cex	numeric. The size of the cue labels.
threshold.cex	numeric. The size of the threshold labels.
decision.cex	numeric. The size of the decision labels.
comp	logical. Should the performance of competitive algorithms (e.g.; logistic regression, random forests etc.) be shown in the ROC plot (if available?)
stats	logical. Should statistical information be plotted? If FALSE, then only the tree (without any reference to statistics) will be plotted.
show.header, show.tree, show.confusion, show.levels, show.roc, show.icons, show.iconguide	logical. Logical arguments indicating which specific elements of the plot to show.
label.tree, label.performance	string. Optional arguments to define labels for the tree and performance section(s).
n.per.icon	Number of cases per icon
which.tree	deprecated argument, only for backwards compatibility, use "tree" instead.
level.type	string. How should bottom levels be drawn? Can be "bar" or "line"
decision.names	deprecated arguments.
...	Currently ignored.

Examples

```
# Create FFTrees of the heart disease data
heart.fft <- FFTrees(formula = diagnosis ~.,
data = heartdisease)

# Visualise the tree
```

```

plot(heart.fft,
     main = "Heart Disease Diagnosis",
     decision.labels = c("Absent", "Present"))

# See the vignette for more details
vignette("FFTrees_plot", package = "FFTrees")

```

predict.FFForest	<i>Predict outcoms from a test dataset using an FFForest object</i>
------------------	---

Description

Predict outcoms from a test dataset using an FFForest object

Usage

```

## S3 method for class 'FFForest'
predict(object = NULL, data = NULL, threshold = 0.5,
        ...)

```

Arguments

object	FFForest. An FFForest object created from the FFForest() function.
data	dataframe. A dataframe of test data
threshold	numeric. A threshold value
...	Additional arguments passed on to predict()

Value

A logical vector of predictions

predict.FFTrees	<i>Predict classifications from newdata using an FFTrees object</i>
-----------------	---

Description

Predict classifications from newdata using an FFTrees object

Usage

```

## S3 method for class 'FFTrees'
predict(object = NULL, newdata = NULL, data = NULL,
        tree = 1, type = "class", sens.w = NULL, method = "laplace", ...)

```

Arguments

object	An FFTrees object created from the FFTrees() function.
newdata	dataframe. A dataframe of test data
tree	integer. Which tree in the object should be used? By default, tree = 1 is used
type	string. What should be predicted? Can be "class", which returns a vector of class predictions, or "prob" which returns a matrix of class probabilities.
sens.w, data	depricated
method	string. Method of calculating class probabilities. Either 'laplace', which applies the Laplace correction, or 'raw' which applies no correction.
...	Additional arguments passed on to predict()

Value

Either a logical vector of predictions, or a matrix of class probabilities.

Examples

```
# Create training and test data

set.seed(100)
breastcancer <- breastcancer[sample(nrow(breastcancer)),]
breast.train <- breastcancer[1:150,]
breast.test <- breastcancer[151:303,]

# Create an FFTrees x from the training data

breast.fft <- FFTrees(formula = diagnosis ~.,
                     data = breast.train)

# Predict classes of test data
breast.fft.pred <- predict(breast.fft,
                          data = breast.test)

# Predict class probabilities
breast.fft.pred <- predict(breast.fft,
                          data = breast.test,
                          type = "prob")
```

print.FFForest

Prints summary information from an FFForest x

Description

Printing function for an FFTrees x

Usage

```
## S3 method for class 'FFForest'
print(x = NULL, ...)
```

Arguments

x FFForest. An FFForest x created from FFForest()
 ... additional arguments passed to print.

print.FFTrees *Prints summary information from an FFTrees object*

Description

Printing function for an FFTrees object

Usage

```
## S3 method for class 'FFTrees'
print(x = NULL, tree = NULL, ...)
```

Arguments

x FFTrees. A FFTrees x created from FFTrees()
 tree integer. The tree to explore.
 ... additional arguments passed to print.

showcues *Visualizes cue accuracies from an FFTrees object in a ROC space*

Description

Visualizes cue accuracies from an FFTrees object in a ROC space

Usage

```
showcues(x = NULL, data = "train", cue.accuracy = NULL, main = NULL,
         top = 5)
```

Arguments

x	An FFTrees object
data	A string indicating whether or not to show training ("train") or testing ("test") cue accuracies
cue.accuracies	dataframe. An optional dataframe specifying cue accuracies directly (without specifying an FFTrees object x)
main	Main plot description
top	An integer indicating how many of the top cues to highlight

sonar	<i>Sonar data set</i>
-------	-----------------------

Description

Sonar data set

Usage

```
sonar
```

Format

A data frame containing 208 rows and 60 columns

Source

[https://archive.ics.uci.edu/ml/datasets/Connectionist+Bench+\(Sonar,+Mines+vs.+Rocks\)](https://archive.ics.uci.edu/ml/datasets/Connectionist+Bench+(Sonar,+Mines+vs.+Rocks))

summary.FFTrees	<i>Returns summary information about an FFTrees object</i>
-----------------	--

Description

Returns summary information about an FFTrees object

Usage

```
## S3 method for class 'FFTrees'
summary(object, tree = 1, ...)
```

Arguments

object	An FFTrees object
tree	integer. The tree to summarise
...	additional arguments (currently ignored)

threshold_factor_grid *Performs a grid search over factor and returns accuracy statistics for a given factor cue*

Description

Performs a grid search over factor and returns accuracy statistics for a given factor cue

Usage

```
threshold_factor_grid(thresholds = NULL, cue.v = NULL, criterion.v = NULL,
  directions = "=", sens.w = 0.5, cost.outcomes = list(hi = 0, fa = 1, mi
    = 1, cr = 0), cost.each = 0, goal.threshold = "bacc")
```

Arguments

thresholds	numeric. A vector of factor thresholds to consider
cue.v	numeric. Feature values
criterion.v	logical. Criterion values
directions	character. Character vector of threshold directions to consider.
sens.w	numeric.
cost.outcomes	list. A list of length 4 with names 'hi', 'fa', 'mi', and 'cr' specifying the costs of a hit, false alarm, miss, and correct rejection respectively. E.g.; cost.outcomes = listc("hi" = 0, "fa" = 10, "mi" = 20, "cr" = 0) means that a false alarm and miss cost 10 and 20 respectively while correct decisions have no cost.
cost.each	numeric.
goal.threshold	character.

threshold_numeric_grid *Performs a grid search over thresholds and returns accuracy statistics for a given numeric cue*

Description

Performs a grid search over thresholds and returns accuracy statistics for a given numeric cue

Usage

```
threshold_numeric_grid(thresholds, cue.v, criterion.v, directions = c(">",
  "<="), sens.w = 0.5, cost.each = 0, cost.outcomes = list(hi = 0, fa = 1,
  mi = 1, cr = 0), goal.threshold = "bacc")
```

Arguments

<code>thresholds</code>	numeric. A vector of thresholds to consider
<code>cue.v</code>	numeric. Feature values
<code>criterion.v</code>	logical. Criterion values
<code>directions</code>	character. Possible directions to consider
<code>sens.w</code>	numeric.
<code>cost.each</code>	numeric. Cost to add to each value (e.g.; cost of the cue)
<code>cost.outcomes</code>	list. A list of length 4 with names 'hi', 'fa', 'mi', and 'cr' specifying the costs of a hit, false alarm, miss, and correct rejection respectively. E.g.; <code>cost.outcomes = listc("hi" = 0, "fa" = 10, "mi" = 20, "cr" = 0)</code> means that a false alarm and miss cost 10 and 20 respectively while correct decisions have no cost.
<code>goal.threshold</code>	character. A string indicating the statistic to maximize when calculating cue thresholds: "acc" = overall accuracy, "wacc" = weighted accuracy, "bacc" = balanced accuracy

titanic

Titanic dataset

Description

A dataset indicating who survived on the Titanic

Usage

```
titanic
```

Format

A data frame containing 2,201 rows and 4 columns

class Factor - Class (first, second, third, or crew)

age Factor - Age group (child or adult)

sex Factor - Sex (male or female)

survived Factor - Whether the passenger survived (1) or not (0)

...

Source

<https://www.amstat.org/publications/jse/datasets/titanic.dat.txt>

updateHistory	<i>Update the history of decisions from trees in an FFTrees object</i>
---------------	--

Description

Update the history of decisions from trees in an FFTrees object

Usage

```
updateHistory(object = NULL, newdata = NULL, tree.definitions = NULL,
              formula = NULL)
```

Arguments

object	FFTrees. An FFTrees object
newdata	dataframe. A dataframe of new data that can be used with <code>predict.FFTrees()</code>
tree.definitions	dataframe. Tree definitions (i.e., from an existing FFTrees object)
formula	formula. Formula used when building FFTrees.

voting	<i>Voting data set</i>
--------	------------------------

Description

Voting data set

Usage

```
voting
```

Format

A data frame containing 435 rows and 16 columns

Source

<https://archive.ics.uci.edu/ml/datasets/Congressional+Voting+Records>

wine	<i>Wine tasting dataset</i>
------	-----------------------------

Description

Chemical and tasting data from wines in North Portugal

Usage

wine

Format

A data frame containing 6497 rows and 13 columns

Source

<http://archive.ics.uci.edu/ml/datasets/Wine+Quality>

wordstoFFT	<i>Converts text describing an FFT into an FFT definition.</i>
------------	--

Description

Converts text describing an FFT into an FFT definition.

Usage

```
wordstoFFT(input, cue.names, decision.labels = NULL)
```

Arguments

input	string. A string describing an FFT in words (see examples)
cue.names	string. A vector of cue names
decision.labels	string. A vector of decision labels

Examples

```
my.tree.def <- wordstoFFT(input = "If age > 55, predict True.  
If cp = {a,b,np}, predict False, otherwise, predict True",  
cue.names = names(heartdisease))
```

Index

*Topic **datasets**

- blood, [4](#)
- breastcancer, [5](#)
- car, [5](#)
- contraceptive, [7](#)
- creditapproval, [8](#)
- fertility, [12](#)
- forestfires, [17](#)
- heart.cost, [20](#)
- heart.fff, [21](#)
- heart.test, [21](#)
- heart.train, [22](#)
- heartdisease, [23](#)
- iris.v, [25](#)
- mushrooms, [26](#)
- sonar, [32](#)
- titanic, [34](#)
- voting, [35](#)
- wine, [36](#)

Add_Stats, [3](#)

apply.tree, [3](#)

blood, [4](#)

breastcancer, [5](#)

car, [5](#)

classtable, [6](#)

comp.pred, [7](#)

contraceptive, [7](#)

creditapproval, [8](#)

cuerank, [9](#)

factclean, [10](#)

fan.algorithm, [10](#)

fertility, [12](#)

FFForest, [12](#)

FFTrees, [14](#)

FFTrees.guide, [17](#)

forestfires, [17](#)

grow.FFTrees, [18](#)

heart.cost, [20](#)

heart.fff, [21](#)

heart.test, [21](#)

heart.train, [22](#)

heartdisease, [23](#)

heuristic.algorithm, [24](#)

inwords, [24](#)

iris.v, [25](#)

mushrooms, [26](#)

plot.FFForest, [27](#)

plot.FFTrees, [27](#)

predict.FFForest, [29](#)

predict.FFTrees, [29](#)

print.FFForest, [30](#)

print.FFTrees, [31](#)

showcues, [31](#)

sonar, [32](#)

summary.FFTrees, [32](#)

threshold_factor_grid, [33](#)

threshold_numeric_grid, [33](#)

titanic, [34](#)

updateHistory, [35](#)

voting, [35](#)

wine, [36](#)

wordstoFFT, [36](#)