

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) using the algorithms and methods described by Phillips, Neth, Woike & Gaissmaier (2017), <[doi:10.1017/S1930297500006239](https://doi.org/10.1017/S1930297500006239)>.

FFTs are simple and transparent decision trees for solving binary classification problems.

FFTs can be preferable to more complex algorithms because they require very little information, are easy to understand and communicate, and are robust against overfitting.

LazyData true

Encoding UTF-8

Depends R(>= 3.5.0)

Imports caret, rpart, randomForest, e1071, cli, dplyr, knitr,
magrittr, scales, stringr, testthat, tibble, tidyselect

Suggests rmarkdown, spelling

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URL <https://CRAN.R-project.org/package=FFTrees>,
<https://github.com/ndphillips/FFTrees/>

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

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Language en-US

NeedsCompilation no

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<code>add_fft_df</code>	<i>Add an FFT definition to tree definitions</i>
-------------------------	--

Description

`add_fft_df` adds the definition(s) of one or more FFT(s) (in the multi-line format of an `FFTrees` object) or a single FFT (as a tidy data frame) to the multi-line FFT definitions of an `FFTrees` object.

`add_fft_df` allows for collecting and combining (sets of) tree definitions after manipulating them with other tree trimming functions.

Usage

```
add_fft_df(fft, ffts_df = NULL, quiet = FALSE)
```

Arguments

<code>fft</code>	A (set of) FFT definition(s) (in the multi-line format of an <code>FFTrees</code> object) or one FFT definition (as a data frame in tidy format, with one row per node).
<code>ffts_df</code>	A set of FFT definitions (as a data frame, usually from an <code>FFTrees</code> object, with suitable variable names to pass <code>verify_ffts_df</code> . Default: <code>ffts_df = NULL</code> .
<code>quiet</code>	Hide feedback messages (as logical)? Default: <code>quiet = FALSE</code> .

Value

A (set of) FFT definition(s) in the one line FFT definition format used by an `FFTrees` object (as a data frame).

See Also

[get_fft_df](#) for getting the FFT definitions of an `FFTrees` object; [read_fft_df](#) for reading one FFT definition from tree definitions; [write_fft_df](#) for writing one FFT to tree definitions; [FFTrees](#) for creating FFTs from and applying them to data.

Other tree definition and manipulation functions: [add_nodes\(\)](#), [drop_nodes\(\)](#), [edit_nodes\(\)](#), [flip_exits\(\)](#), [get_fft_df\(\)](#), [read_fft_df\(\)](#), [reorder_nodes\(\)](#), [select_nodes\(\)](#), [write_fft_df\(\)](#)

add_nodes *Add nodes to an FFT definition*

Description

add_nodes allows adding one or more nodes to an existing FFT definition (in the tidy data frame format).

add_nodes allows to directly set and change the value(s) of class, cue, direction, threshold, and exit, in an FFT definition for the specified nodes.

There is only rudimentary verification for plausible entries. Importantly, however, as add_nodes is ignorant of data, the values of its variables are not validated for a specific set of data.

Values in nodes refer to their new position in the final FFT. Duplicate values of nodes are ignored (and only the last entry is used).

When a new exit node is added, the exit type of a former final node is set to the signal value (i.e., exit_types[2]).

Usage

```
add_nodes(
  fft,
  nodes = NA,
  class = NA,
  cue = NA,
  direction = NA,
  threshold = NA,
  exit = NA,
  quiet = FALSE
)
```

Arguments

fft	One FFT definition (as a data frame in tidy format, with one row per node).
nodes	The FFT nodes to be added (as an integer vector). Values refer to their new position in the final FFT (i.e., after adding all nodes to fft). Default: nodes = NA.
class	The class values of nodes (as character).
cue	The cue names of nodes (as character).
direction	The direction values of nodes (as character).
threshold	The threshold values of nodes (as character).
exit	The exit values of nodes (as values from exit_types).
quiet	Hide feedback messages (as logical)? Default: quiet = FALSE.

Value

One FFT definition (as a data frame in tidy format, with one row per node).

See Also

[drop_nodes](#) for deleting nodes from an FFT definition; [edit_nodes](#) for editing nodes in an FFT definition; [flip_exits](#) for reversing exits in an FFT definition; [reorder_nodes](#) for reordering nodes of an FFT definition; [select_nodes](#) for selecting nodes in an FFT definition; [get_fft_df](#) for getting the FFT definitions of an FFTrees object; [read_fft_df](#) for reading one FFT definition from tree definitions; [add_fft_df](#) for adding FFTs to tree definitions; [FFTrees](#) for creating FFTs from and applying them to data.

Other tree definition and manipulation functions: [add_fft_df\(\)](#), [drop_nodes\(\)](#), [edit_nodes\(\)](#), [flip_exits\(\)](#), [get_fft_df\(\)](#), [read_fft_df\(\)](#), [reorder_nodes\(\)](#), [select_nodes\(\)](#), [write_fft_df\(\)](#)

add_stats	<i>Add decision statistics to data (based on frequency counts of a 2x2 classification outcomes)</i>
-----------	---

Description

add_stats assumes the input of the 4 essential classification outcomes (as frequency counts in a data frame "data" with variable names "hi", "fa", "mi", and "cr") and uses them to compute various decision accuracy measures.

Usage

```
add_stats(
  data,
  correction = 0.25,
  sens.w = NULL,
  my.goal = NULL,
  my.goal.fun = NULL,
  cost.outcomes = NULL,
  cost.each = NULL
)
```

Arguments

data	A data frame with 4 frequency counts (as integer values, named "hi", "fa", "mi", and "cr").
correction	numeric. Correction added to all counts for calculating dprime. Default: correction = .25.
sens.w	numeric. Sensitivity weight (for computing weighted accuracy, wacc). Default: sens.w = NULL (to ensure that values are passed by calling function).
my.goal	Name of an optional, user-defined goal (as character string). Default: my.goal = NULL.
my.goal.fun	User-defined goal function (with 4 arguments hi fa mi cr). Default: my.goal.fun = NULL.

<code>cost.outcomes</code>	list. A list of length 4 named "hi", "fa", "mi", "cr", and 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 units, respectively, while correct decisions incur no costs. Default: <code>cost.outcomes = NULL</code> (to ensure that values are passed by calling function).
<code>cost.each</code>	numeric. An optional fixed cost added to all outputs (e.g., the cost of using the cue). Default: <code>cost.each = NULL</code> (to ensure that values are passed by calling function).

Details

Providing numeric values for `cost.each` (as a vector) and `cost.outcomes` (as a named list) allows computing cost information for the counts of corresponding classification decisions.

Value

A data frame with variables of computed accuracy and cost measures (but dropping inputs).

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

Description

Data taken from the Blood Transfusion Service Center in Hsin-Chu City in Taiwan

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 *Criterion:* Did the person donate blood (in March 2007)?

Values: 0/no vs. 1/yes (76.2% vs.\ 23.8%).

Source

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

Original owner and donor:

Prof. I-Cheng Yeh

Department of Information Management

Chung-Hua University

See Also

Other datasets: [breastcancer](#), [car](#), [contraceptive](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heart.train](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [sonar](#), [titanic](#), [voting](#), [wine](#)

breastcancer

Physiological data of patients tested for breast cancer

Description

Physiological data of patients tested for breast cancer

Usage

breastcancer

Format

A data frame containing 699 patients (rows) and 9 variables (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 *Criterion:* Absence/presence of breast cancer.

Values: FALSE vs. TRUE (65.0% vs.\ 35.0%).

Details

We made the following enhancements to the original data for improved usability:

- The ID number of the cases was excluded.
- The numeric criterion with value "2" for benign and "4" for malignant was converted to logical TRUE/FALSE.
- 16 cases were excluded because they contained NAs.

Other than that, the data remains consistent with the original dataset.

Source

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

Original creator:

Dr. William H. Wolberg (physician)

University of Wisconsin Hospitals

Madison, Wisconsin, USA

See Also

Other datasets: [blood](#), [car](#), [contraceptive](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heart.train](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [sonar](#), [titanic](#), [voting](#), [wine](#)

car

Car acceptability data

Description

A dataset on car evaluations based on basic features, derived from a simple hierarchical decision model.

Usage

car

Format

A data frame containing 1728 cars (rows) and 7 variables (columns).

buying.price price for buying the car, Factor (high, low, med, vhigh)

maint.price price of the maintenance, Factor (high, low, med, vhigh)

doors number of doors, Factor (2, 3, 4, 5more)

persons capacity in terms of persons to carry, Factor (2, 4, more)

luggage the size of luggage boot, Factor (big, med, small)

safety estimated safety of the car, Factor (high, low, med)

acceptability *Criterion*: Category of acceptability rating.

Values: unacc/ vgood/ good/ acc

Details

The criterion variable is a car's acceptability rating.

The *criterion* for this dataset has not yet been binarized. Before using it with an *FFTree*, this necessary prerequisite step should be completed based on individual preferences.

Source

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

Original creator and donor:

Marko Bohanec and Blaz Zupan

References

Bohanec, M., Rajkovic, V. (1990): Expert system for decision making. *Sistemica*, 1 (1), 145–157.

See Also

Other datasets: [blood](#), [breastcancer](#), [contraceptive](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heart.train](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [sonar](#), [titanic](#), [voting](#), [wine](#)

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

Description

The main input are 2 logical vectors of prediction and criterion values.

Usage

```
classtable(
  prediction_v = NULL,
  criterion_v = NULL,
  correction = 0.25,
  sens.w = NULL,
  cost.outcomes = NULL,
  cost_v = NULL,
  my.goal = NULL,
  my.goal.fun = NULL,
  quiet_mis = FALSE,
  na_prediction_action = "ignore"
)
```

Arguments

prediction_v	logical. A logical vector of predictions.
criterion_v	logical. A logical vector of (TRUE) criterion values.
correction	numeric. Correction added to all counts for calculating dprime. Default: correction = .25.
sens.w	numeric. Sensitivity weight parameter (from 0 to 1, for computing wacc). Default: sens.w = NULL (to ensure that values are passed by calling function).

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. For instance, <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. Default: <code>cost.outcomes = NULL</code> (to ensure that values are passed by calling function).
cost_v	numeric. Additional cost value of each decision (as an optional vector of numeric values). Typically used to include the cue cost of each decision (as a constant for the current level of an FFT). Default: <code>cost_v = NULL</code> (to ensure that values are passed by calling function).
my.goal	Name of an optional, user-defined goal (as character string). Default: <code>my.goal = NULL</code> .
my.goal.fun	User-defined goal function (with 4 arguments hi fa mi cr). Default: <code>my.goal.fun = NULL</code> .
quiet_mis	A logical value passed to hide/show NA user feedback (usually <code>x\$params\$quiet\$mis</code> of the calling function). Default: <code>quiet_mis = FALSE</code> (i.e., show user feedback).
na_prediction_action	What happens when no prediction is possible? (Experimental and currently unused.)

Details

The primary confusion matrix is computed by `confusionMatrix` of the **caret** package.

comp_pred

Fit and predict competing classification algorithms

Description

`comp_pred` provides a wrapper for running (i.e., fit or predict) alternative classification algorithms to data (i.e., `data.train` or `data.test`, respectively).

Usage

```
comp_pred(
  formula,
  data.train,
  data.test = NULL,
  algorithm = NULL,
  model = NULL,
  sens.w = NULL,
  new.factors = "exclude",
  quiet_mis = FALSE
)
```

Arguments

<code>formula</code>	A formula (usually <code>x\$formula</code> , for an <code>FFTrees</code> object <code>x</code>).
<code>data.train</code>	A training dataset (as a data frame).
<code>data.test</code>	A testing dataset (as a data frame).
<code>algorithm</code>	A character string specifying an algorithm in the set: <ul style="list-style-type: none"> • <code>"lr"</code>: Logistic regression (using <code>glm</code> from stats with <code>family = "binomial"</code>); • <code>"r1r"</code>: Regularized logistic regression (currently not supported); • <code>"cart"</code>: Decision trees (using <code>rpart</code> from rpart); • <code>"svm"</code>: Support vector machines (using <code>svm</code> from e1071); • <code>"rf"</code>: Random forests (using <code>randomForest</code> from randomForest).
<code>model</code>	An optional existing model (as a model), to be applied to the test data.
<code>sens.w</code>	Sensitivity weight parameter (numeric, from 0 to 1), required to compute <code>wacc</code> .
<code>new.factors</code>	What should be done if new factor values are discovered in the test set (as a character string)? Available options: <ul style="list-style-type: none"> • <code>"exclude"</code>: exclude case (i.e., remove these cases, used by default); • <code>"base"</code>: predict the base rate of the criterion.
<code>quiet_mis</code>	A logical value passed to hide/show NA user feedback (usually <code>x\$params\$quiet\$mis</code> of the calling function). Default: <code>quiet_mis = FALSE</code> (i.e., show user feedback).

Details

The range of competing algorithms currently available includes logistic regression (`stats::glm`), CART (`rpart::rpart`), support vector machines (`e1071::svm`), and random forests (`randomForest::randomForest`).

The current support for handling missing data (or NA values) is only rudimentary. When enabled (via the global options `allow_NA_pred` or `allow_NA_crit`), any rows in `data.train` or `data.test` with incomplete cases are being removed prior to fitting or predicting a model (by using `na.omit` from **stats**). See the specifications of each model for more sophisticated ways of handling missing data.

contraceptive

Contraceptive use data

Description

A subset of the 1987 National Indonesia Contraceptive Prevalence Survey.

Usage

`contraceptive`

Format

A data frame containing 1473 cases (rows) and 10 variables (columns).

wife.age Wife's age, Numeric

wife.edu Wife's education, Numeric, (1=low, 2, 3, 4=high)

hus.ed Husband's education, Numeric, (1=low, 2, 3, 4=high)

children Number of children ever born, Numeric

wife.rel Wife's religion, Numeric, (0=Non-Islam, 1=Islam)

wife.work Wife's now working?, Numeric, (0=Yes, 1=No)

hus.occ Husband's occupation, Numeric, (1, 2, 3, 4)

sol Standard-of-living index, Numeric, (1=low, 2, 3, 4=high)

media Media exposure, Numeric, (0=Good, 1=Not good)

cont.crit *Criterion*: Use of a contraceptive (as logical).

Values: FALSE vs. TRUE (42.7% vs. 57.3%).

Details

The samples describe married women who were either not pregnant or do not know if they were pregnant at the time of the interview.

The problem consists in predicting a woman's current contraceptive method choice (here: binarized `cont.crit`) based on her demographic and socio-economic characteristics.

We made the following enhancements to the original data for improved usability:

- The criterion was binarized from a class attribute variable with three levels (1=No-use, 2=Long-term, 3=Short-term), into a logical variable with two levels (TRUE vs. FALSE).

Other than that, the data remains consistent with the original dataset.

Source

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

Original creator and donor:

Tjen-Sien Lim

See Also

Other datasets: [blood](#), [breastcancer](#), [car](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heart.train](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [sonar](#), [titanic](#), [voting](#), [wine](#)

creditapproval	<i>Credit approval data</i>
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Description

This data reports predictors and the result of credit card applications. Its attribute names and values have been changed to symbols to protect confidentiality.

Usage

creditapproval

Format

A data frame containing 690 cases (rows) and 15 variables (columns).

- c.1** categorical: b, a
- c.2** continuous
- c.3** continuous
- c.4** categorical: u, y, l, t
- c.5** categorical: g, p, gg
- c.6** categorical: c, d, cc, i, j, k, m, r, q, w, x, e, aa, ff
- c.7** categorical: v, h, bb, j, n, z, dd, ff, o
- c.8** continuous
- c.9** categorical: t, f
- c.10** categorical: t, f
- c.11** continuous
- c.12** categorical: t, f
- c.13** categorical: g, p, s
- c.14** continuous
- c.15** continuous
- crit** *Criterion*: Credit approval.
Values: TRUE (+) vs. FALSE (-) (44.5% vs. 55.5%).

Details

This dataset contains a mix of attributes – continuous, nominal with small Ns, and nominal with larger Ns. There are also a few missing values.

We made the following enhancements to the original data for improved usability:

- Any missing values, denoted as "?" in the dataset, were transformed into NAs.
- Binary factor variables with exclusive "t" and "f" values were converted to logical TRUE/FALSE vectors.

Other than that, the data remains consistent with the original dataset.

Source

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

See Also

Other datasets: [blood](#), [breastcancer](#), [car](#), [contraceptive](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heart.train](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [sonar](#), [titanic](#), [voting](#), [wine](#)

describe_data

Describe data

Description

Calculate key descriptive statistics for a given set of data.

Usage

```
describe_data(data, data_name, criterion_name, baseline_value)
```

Arguments

`data` A data frame with a criterion variable `criterion_name`.
`data_name` A character string specifying a name for the data.
`criterion_name` A character string specifying the criterion name.
`baseline_value` The value in `criterion_name` denoting the baseline (e.g., TRUE or FALSE).

Value

A data frame with the descriptive statistics.

Examples

```
data(heartdisease)
describe_data(heartdisease, "heartdisease",
              criterion_name = "diagnosis",
              baseline_value = TRUE)
```

drop_nodes	<i>Drop a node from an FFT definition</i>
------------	---

Description

drop_nodes deletes one or more nodes from an existing FFT definition (by removing the corresponding rows from the FFT definition in the tidy data frame format).

When dropping the final node, the last remaining node becomes the new final node (i.e., gains a second exit).

Duplicates in nodes are dropped only once (rather than incrementally) and nodes not in the range 1:nrow(fft) are ignored. Dropping all nodes yields an error.

drop_nodes is the inverse function of [select_nodes](#). Inserting new nodes is possible by [add_nodes](#).

Usage

```
drop_nodes(fft, nodes = NA, quiet = FALSE)
```

Arguments

fft	One FFT definition (as a data frame in tidy format, with one row per node).
nodes	The FFT nodes to drop (as an integer vector). Default: nodes = NA.
quiet	Hide feedback messages (as logical)? Default: quiet = FALSE.

Value

One FFT definition (as a data frame in tidy format, with one row per node).

See Also

[add_nodes](#) for adding nodes to an FFT definition; [edit_nodes](#) for editing nodes in an FFT definition; [select_nodes](#) for selecting nodes in an FFT definition; [get_fft_df](#) for getting the FFT definitions of an FFTrees object; [read_fft_df](#) for reading one FFT definition from tree definitions; [add_fft_df](#) for adding FFTs to tree definitions; [FFTrees](#) for creating FFTs from and applying them to data.

Other tree definition and manipulation functions: [add_fft_df\(\)](#), [add_nodes\(\)](#), [edit_nodes\(\)](#), [flip_exits\(\)](#), [get_fft_df\(\)](#), [read_fft_df\(\)](#), [reorder_nodes\(\)](#), [select_nodes\(\)](#), [write_fft_df\(\)](#)

`edit_nodes`*Edit nodes in an FFT definition*

Description

`edit_nodes` allows manipulating one or more nodes from an existing FFT definition (in the tidy data frame format).

`edit_nodes` allows to directly set and change the value(s) of `class`, `cue`, `direction`, `threshold`, and `exit`, in an FFT definition for the specified nodes.

There is only rudimentary verification for plausible entries. Importantly, however, as `edit_nodes` is ignorant of data, the values of its variables are not validated for a specific set of data.

Repeated changes of a node are possible (by repeating the corresponding integer value in `nodes`).

Usage

```
edit_nodes(  
  fft,  
  nodes = NA,  
  class = NA,  
  cue = NA,  
  direction = NA,  
  threshold = NA,  
  exit = NA,  
  quiet = FALSE  
)
```

Arguments

<code>fft</code>	One FFT definition (as a data frame in tidy format, with one row per node).
<code>nodes</code>	The FFT nodes to be edited (as an integer vector). Default: <code>nodes = NA</code> .
<code>class</code>	The class values of nodes (as character).
<code>cue</code>	The cue names of nodes (as character).
<code>direction</code>	The direction values of nodes (as character).
<code>threshold</code>	The threshold values of nodes (as character).
<code>exit</code>	The exit values of nodes (as values from <code>exit_types</code>).
<code>quiet</code>	Hide feedback messages (as logical)? Default: <code>quiet = FALSE</code> .

Value

One FFT definition (as a data frame in tidy format, with one row per node).

See Also

[add_nodes](#) for adding nodes to an FFT definition; [drop_nodes](#) for deleting nodes from an FFT definition; [flip_exits](#) for reversing exits in an FFT definition; [reorder_nodes](#) for reordering nodes of an FFT definition; [select_nodes](#) for selecting nodes in an FFT definition; [get_fft_df](#) for getting the FFT definitions of an FFTrees object; [read_fft_df](#) for reading one FFT definition from tree definitions; [add_fft_df](#) for adding FFTs to tree definitions; [FFTrees](#) for creating FFTs from and applying them to data.

Other tree definition and manipulation functions: [add_fft_df\(\)](#), [add_nodes\(\)](#), [drop_nodes\(\)](#), [flip_exits\(\)](#), [get_fft_df\(\)](#), [read_fft_df\(\)](#), [reorder_nodes\(\)](#), [select_nodes\(\)](#), [write_fft_df\(\)](#)

fact_clean	<i>Clean factor variables in prediction data</i>
------------	--

Description

Clean factor variables in prediction data

Usage

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

Arguments

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

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

Description

This dataset describes a sample of 100 volunteers providing a semen sample that was analyzed according to the WHO 2010 criteria.

Usage

```
fertility
```

Format

A data frame containing 100 rows and 10 columns.

season Season in which the analysis was performed. (winter, spring, summer, fall)

age Age at the time of analysis

child.dis Childish diseases (ie , chicken pox, measles, mumps, polio) (yes(1), no(0))

trauma Accident or serious trauma (yes(1), no(0))

surgery Surgical intervention (yes(1), no(0))

fevers High fevers in the last year (less than three months ago(-1), more than three months ago (0), no. (1))

alcohol Frequency of alcohol consumption (several times a day, every day, several times a week, once a week, hardly ever or never)

smoking Smoking habit (never(-1), occasional (0)) daily (1))

sitting Number of hours spent sitting per day

diagnosis *Criterion:* Diagnosis normal (TRUE) vs. altered (FALSE) (88.0% vs.\ 22.0%).

Details

Sperm concentration are related to socio-demographic data, environmental factors, health status, and life habits.

We made the following enhancements to the original data for improved usability:

- The criterion was redefined from a factor variable with two levels (N=Normal, 0=Altered) into a logical variable (TRUE vs. FALSE).

Other than that, the data remains consistent with the original dataset.

Source

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

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See Also

Other datasets: [blood](#), [breastcancer](#), [car](#), [contraceptive](#), [creditapproval](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heart.train](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [sonar](#), [titanic](#), [voting](#), [wine](#)

`FFTrees`*Main function to create and apply fast-and-frugal trees (FFTs)*

Description

FFTrees is the workhorse function of the **FFTrees** package for creating fast-and-frugal trees (FFTs).

FFTs are decision algorithms for solving binary classification tasks, i.e., they predict the values of a binary criterion variable based on 1 or multiple predictor variables (cues).

Using FFTrees on data usually generates a range of FFTs and corresponding summary statistics (as an FFTrees object) that can then be printed, plotted, and examined further.

The criterion and predictor variables are specified in `formula` notation. Based on the settings of `data` and `data.test`, FFTs are trained on a (required) training dataset (given the set of current goal values) and evaluated on (or predict) an (optional) test dataset.

If an existing FFTrees object `object` or `tree.definitions` are provided as inputs, no new FFTs are created. When both arguments are provided, `tree.definitions` take priority over the FFTs in an existing object. Specifically,

- If `tree.definitions` are provided, these are assigned to the FFTs of `x`.
- If no `tree.definitions` are provided, but an existing FFTrees object `object` is provided, the trees from `object` are assigned to the FFTs of `x`.

Create and evaluate fast-and-frugal trees (FFTs).

Usage

```
FFTrees(  
  formula = NULL,  
  data = NULL,  
  data.test = NULL,  
  algorithm = "ifan",  
  train.p = 1,  
  goal = NULL,  
  goal.chase = NULL,  
  goal.threshold = NULL,  
  max.levels = NULL,  
  numthresh.method = "o",  
  numthresh.n = 10,  
  repeat.cues = TRUE,  
  stopping.rule = "exemplars",  
  stopping.par = 0.1,  
  sens.w = 0.5,  
  cost.outcomes = NULL,  
  cost.cues = NULL,  
  main = NULL,  
  decision.labels = c("False", "True"),
```

```

my.goal = NULL,
my.goal.fun = NULL,
my.tree = NULL,
object = NULL,
tree.definitions = NULL,
do.comp = TRUE,
do.cart = TRUE,
do.lr = TRUE,
do.rf = TRUE,
do.svm = TRUE,
quiet = list(ini = TRUE, fin = FALSE, mis = FALSE, set = TRUE),
comp = NULL,
force = NULL,
rank.method = NULL,
rounding = NULL,
store.data = NULL,
verbose = NULL
)

```

Arguments

formula	A formula. A formula specifying a binary criterion variable (as logical) as a function of 1 or more predictor variables (cues).
data	A data frame. A dataset used for training (fitting) FFTs and alternative algorithms. data must contain the binary criterion variable specified in formula and potential predictors (which can be categorical or numeric variables).
data.test	A data frame. An optional dataset used for model testing (prediction) with the same structure as data.
algorithm	A character string. The algorithm used to create FFTs. Can be 'ifan', 'dfan'.
train.p	numeric. What percentage of the data to use for training when data.test is not specified? For example, train.p = .50 will randomly split data into a 50% training set and a 50% test set. Default: train.p = 1 (i.e., using <i>all</i> data for training).
goal	A character string indicating the statistic to maximize when <i>selecting trees</i> : "acc" = overall accuracy, "bacc" = balanced accuracy, "wacc" = weighted accuracy, "dprime" = discriminability, "cost" = costs (based on cost.outcomes and cost.cues).
goal.chase	A character string indicating the statistic to maximize when <i>constructing trees</i> : "acc" = overall accuracy, "bacc" = balanced accuracy, "wacc" = weighted accuracy, "dprime" = discriminability, "cost" = costs (based on cost.outcomes and cost.cues).
goal.threshold	A character string indicating the criterion to maximize when <i>optimizing cue thresholds</i> : "acc" = overall accuracy, "bacc" = balanced accuracy, "wacc" = weighted accuracy, "dprime" = discriminability, "cost" = costs (based only on cost.outcomes, as cost.cues are constant per cue). All default goals are set in fftrees_create .

<code>max.levels</code>	integer. The maximum number of nodes (or levels) considered for an FFT. As all combinations of possible exit structures are considered, larger values of <code>max.levels</code> will create larger sets of FFTs.
<code>numthresh.method</code>	How should thresholds for numeric cues be determined (as character)? "o" will optimize thresholds (for <code>goal.threshold</code>), while "m" will use the median. Default: <code>numthresh.method = "o"</code> .
<code>numthresh.n</code>	The number of numeric thresholds to try (as integer). Default: <code>numthresh.n = 10</code> .
<code>repeat.cues</code>	May cues occur multiple times within a tree (as logical)? Default: <code>repeat.cues = TRUE</code> .
<code>stopping.rule</code>	A character string indicating the method to stop growing trees. Available options are: <ul style="list-style-type: none"> • "exemplars": A tree grows until only a small proportion of unclassified exemplars remain; • "levels": A tree grows until a certain level is reached; • "statdelta": A tree grows until the change in the criterion statistic <code>goal.chase</code> exceeds some threshold level. (This setting is currently experimental and includes the first level beyond threshold. As tree statistics can be non-monotonic, this option may yield inconsistent results.) <p>All stopping methods use <code>stopping.par</code> to set a numeric threshold value. Default: <code>stopping.rule = "exemplars"</code>.</p>
<code>stopping.par</code>	numeric. A numeric parameter indicating the criterion value for the current <code>stopping.rule</code> . For <code>stopping.rule "levels"</code> , this is the number of desired levels (as an integer). For <code>stopping.rule "exemplars"</code> , this is the smallest proportion of exemplars allowed in the last level. For <code>stopping.rule "statdelta"</code> , this is the minimum required change (in the <code>goal.chase</code> value) to include a level. Default: <code>stopping.par = .10</code> .
<code>sens.w</code>	A numeric value from 0 to 1 indicating how to weight sensitivity relative to specificity when optimizing <i>weighted</i> accuracy (e.g., <code>goal = 'wacc'</code>). Default: <code>sens.w = .50</code> (i.e., <code>wacc</code> corresponds to <code>bacc</code>).
<code>cost.outcomes</code>	A list of length 4 specifying the cost value for one of the 4 possible classification outcomes. The list elements must be named 'hi', 'fa', 'mi', and 'cr' (for specifying the costs of a hit, false alarm, miss, and correct rejection, respectively) and provide a numeric cost value. E.g.; <code>cost.outcomes = listc("hi" = 0, "fa" = 10, "mi" = 20, "cr" = 0)</code> imposes false alarm and miss costs of 10 and 20 units, respectively, while correct decisions have no costs.
<code>cost.cues</code>	A list containing the cost of each cue (in some common unit). Each list element must have a name corresponding to a cue (i.e., a variable in data), and should be a single (positive numeric) value. Cues in data that are not present in <code>cost.cues</code> are assumed to have no costs (i.e., a cost value of 0).
<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>decision.labels</code>	A vector of strings of length 2 for the text labels for negative and positive decision/prediction outcomes (i.e., left vs. right, noise vs. signal, 0 vs. 1, respectively, as character). E.g.; <code>decision.labels = c("Healthy", "Diseased")</code> .
<code>my.goal</code>	The name of an optimization measure defined by <code>my.goal.fun</code> (as a character string). Example: <code>my.goal = "my_acc"</code> (see <code>my.goal.fun</code> for corresponding function). Default: <code>my.goal = NULL</code> .
<code>my.goal.fun</code>	The definition of an outcome measure to optimize, defined as a function of the frequency counts of the 4 basic classification outcomes <code>hi</code> , <code>fa</code> , <code>mi</code> , <code>cr</code> (i.e., an R function with 4 arguments <code>hi</code> , <code>fa</code> , <code>mi</code> , <code>cr</code>). Example: <code>my.goal.fun = function(hi, fa, mi, cr){(hi + cr)/(hi + fa + mi + cr)}</code> (i.e., accuracy). Default: <code>my.goal.fun = NULL</code> .
<code>my.tree</code>	A verbal description of an FFT, i.e., an "FFT in words" (as character string). For example, <code>my.tree = "If age > 20, predict TRUE. If sex = {m}, predict FALSE. Otherwise, predict TRUE."</code> .
<code>object</code>	An optional existing FFTrees object. When specified, no new FFTs are fitted, but existing trees are applied to <code>data</code> and <code>data.test</code> . When <code>formula</code> , <code>data</code> or <code>data.test</code> are not specified, the current values of <code>object</code> are used.
<code>tree.definitions</code>	An optional <code>data.frame</code> of hard-coded FFT definitions (in the format of <code>x\$trees\$definitions</code> of an FFTrees object <code>x</code>). If specified, no new FFTs are being fitted (i.e., <code>algorithm</code> and functions for evaluating cues and creating FFTs are skipped). Instead, the tree definitions provided are used to re-evaluate the current FFTrees object on current data.
<code>do.comp</code> , <code>do.lr</code> , <code>do.cart</code> , <code>do.svm</code> , <code>do.rf</code>	Should alternative algorithms be used for comparison (as logical)? All options are set to TRUE by default. Available options correspond to: <ul style="list-style-type: none"> • <code>do.lr</code>: Logistic regression (LR, using <code>glm</code> from stats with <code>family = "binomial"</code>); • <code>do.cart</code>: Classification and regression trees (CART, using <code>rpart</code> from rpart); • <code>do.svm</code>: Support vector machines (SVM, using <code>svm</code> from e1071); • <code>do.rf</code>: Random forests (RF, using <code>randomForest</code> from randomForest). Specifying <code>do.comp = FALSE</code> sets all available options to FALSE.
<code>quiet</code>	A list of 4 logical arguments: Should detailed progress reports be suppressed? Setting list elements to FALSE is helpful when diagnosing errors. Default: <code>quiet = list(ini = TRUE, fin = FALSE, mis = FALSE, set = TRUE)</code> , for initial vs. final steps, missing cases, and parameter settings, respectively. Providing a single logical value sets all elements to TRUE or FALSE.
<code>comp</code> , <code>force</code> , <code>rank.method</code> , <code>rounding</code> , <code>store.data</code> , <code>verbose</code>	Deprecated arguments (unused or replaced, to be retired in future releases).

Value

An FFTrees object with the following elements:

criterion_name The name of the binary criterion variable (as character).

- cue_names** The names of all potential predictor variables (cues) in the data (as character).
- formula** The [formula](#) specified when creating the FFTs.
- trees** A list of FFTs created, with further details contained in `n`, `best`, `definitions`, `inwords`, `stats`, `level_stats`, and `decisions`.
- data** The original training and test data (if available).
- params** A list of defined control parameters (e.g.; `algorithm`, `goal`, `sens.w`, as well as various thresholds, stopping rule, and cost parameters).
- competition** Models and classification statistics for competitive classification algorithms: Logistic regression (`lr`), classification and regression trees (`cart`), random forests (`rf`), and support vector machines (`svm`).
- cues** A list of cue information, with further details contained in `thresholds` and `stats`.

See Also

[print.FFTrees](#) for printing FFTs; [plot.FFTrees](#) for plotting FFTs; [summary.FFTrees](#) for summarizing FFTs; [inwords](#) for obtaining a verbal description of FFTs; [showcues](#) for plotting cue accuracies.

Examples

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

# 2. Print a summary of the result:
heart.fft # same as:
# print(heart.fft, data = "train", tree = "best.train")

# 3. Plot an FFT applied to training data:
plot(heart.fft) # same as:
# plot(heart.fft, what = "all", data = "train", tree = "best.train")

# 4. Apply FFT to (new) testing data:
plot(heart.fft, data = "test") # predict for Tree 1
plot(heart.fft, data = "test", tree = 2) # predict for Tree 2

# 5. Predict classes and probabilities for new data:
predict(heart.fft, newdata = heartdisease)
predict(heart.fft, newdata = heartdisease, type = "prob")

# 6. Create a custom tree (from verbal description) with my.tree:
custom.fft <- FFTrees(
  formula = diagnosis ~ .,
  data = heartdisease,
  my.tree = "If age < 50, predict False.
```

```

                If sex = 1, predict True.
                If chol > 300, predict True, otherwise predict False.",
main = "My custom FFT")

# Plot the (pretty bad) custom tree:
plot(custom.fft)

```

FFTrees.guide	<i>Open the FFTrees package guide</i>
---------------	---------------------------------------

Description

Open the **FFTrees** package guide

Usage

```
FFTrees.guide()
```

Value

No return value, called for side effects.

fftrees_cuerank	<i>Calculate thresholds that optimize some statistic (goal) for cues in data</i>
-----------------	--

Description

fftrees_cuerank takes an FFTrees object `x` and optimizes its `goal.threshold` (from `x$params`) for all cues in `newdata` (of type `data`).

Usage

```
fftrees_cuerank(x = NULL, newdata = NULL, data = "train", rounding = NULL)
```

Arguments

<code>x</code>	An FFTrees object.
<code>newdata</code>	A dataset with cues to be ranked (as data frame).
<code>data</code>	The type of data with cues to be ranked (as character: 'train', 'test', or 'dynamic'). Default: <code>data = 'train'</code> .
<code>rounding</code>	integer. An integer value indicating the decimal digit to which non-integer numeric cue thresholds are to be rounded. Default: <code>rounding = NULL</code> (i.e., no rounding).

Details

ffttrees_cuerank creates a data frame cuerank_df that is added to x\$cues\$stats.

Note that the cue directions and thresholds computed by **FFTrees** always predict positive criterion values (i.e., TRUE or signal, rather than FALSE or noise). Using these thresholds for negative exits (i.e., for predicting instances of FALSE or noise) usually requires a reversal (e.g., negating cue direction).

ffttrees_cuerank is called (twice) by the fftrees_grow_fan algorithm to grow fast-and-frugal trees (FFTs).

Value

A modified FFTrees object (with cue rank information for the current data type in x\$cues\$stats).

ffttrees_ffttowords *Describe a fast-and-frugal tree (FFT) in words*

Description

ffttrees_ffttowords provides a verbal description of tree definition (as defined in an FFTrees object). Thus, fftrees_ffttowords translates an abstract FFT definition into natural language output.

ffttrees_ffttowords is the complement function to [ffttrees_wordstoftrees](#), which parses a verbal description of an FFT into the abstract tree definition of an FFTrees object.

The final sentence (or tree node) of the FFT's description always predicts positive criterion values (i.e., TRUE instances) first, before predicting negative criterion values (i.e., FALSE instances). Note that this may require a reversal of exit directions, if the final cue predicted FALSE instances.

Note that the cue directions and thresholds computed by **FFTrees** always predict positive criterion values (i.e., TRUE or signal, rather than FALSE or noise). Using these thresholds for negative exits (i.e., for predicting instances of FALSE or noise) usually requires a reversal (e.g., negating cue direction).

Usage

```
ffttrees_ffttowords(x = NULL, mydata = "train", digits = 2)
```

Arguments

x	An FFTrees object created with FFTrees .
mydata	The type of data to which a tree is being applied (as character string "train" or "test"). Default: mydata = "train".
digits	How many digits to round numeric values (as integer)?

Value

A modified FFTrees object x with x\$trees\$inwords containing a list of string vectors.

See Also

[fftrees_wordstoefftrees](#) for converting a verbal description of an FFT into an FFTrees object; [fftrees_create](#) for creating FFTrees objects; [fftrees_grow_fan](#) for creating FFTs by applying algorithms to data; [print.FFTrees](#) for printing FFTs; [plot.FFTrees](#) for plotting FFTs; [summary.FFTrees](#) for summarizing FFTs; [FFTrees](#) for creating FFTs from and applying them to data.

Examples

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

inwords(heart.fft)
```

fftrees_fitcomp

Fit competitive algorithms

Description

fftrees_fitcomp fits competitive algorithms for binary classification tasks (e.g., LR, CART, RF, SVM) to the data and parameters specified in an FFTrees object.

fftrees_fitcomp is called by the main [FFTrees](#) function when creating FFTs from and applying them to data (unless `do.comp = FALSE`).

Usage

```
fftrees_fitcomp(x)
```

Arguments

x An FFTrees object.

See Also

[FFTrees](#) for creating FFTs from and applying them to data.

ffttrees_grow_fan *Grow fast-and-frugal trees (FFTs) using the fan algorithms*

Description

ffttrees_grow_fan is called by [ffttrees_define](#) to create new FFTs by applying the fan algorithms (specifically, either ifan or dfan) to data.

Usage

```
ffttrees_grow_fan(x, repeat.cues = TRUE)
```

Arguments

x	An FFTrees object.
repeat.cues	Can cues be considered/used repeatedly (as logical)? Default: repeat.cues = TRUE, but only relevant when using the dfan algorithm.

See Also

[ffttrees_create](#) for creating FFTrees objects; [ffttrees_define](#) for defining FFTs; [ffttrees_grow_fan](#) for creating FFTs by applying algorithms to data; [ffttrees_wordstoftrees](#) for creating FFTs from verbal descriptions; [FFTrees](#) for creating FFTs from and applying them to data.

ffttrees_ranktrees *Rank FFTs by current goal*

Description

ffttrees_ranktrees ranks trees in an FFTrees object x based on the current goal (either "cost" or as specified in x\$params\$goal).

ffttrees_ranktrees is called by the main [FFTrees](#) function when creating FFTs from and applying them to (training) data.

Usage

```
ffttrees_ranktrees(x, data = "train")
```

Arguments

x	An FFTrees object.
data	The type of data to be used (as character). Default: data = "train".

See Also

[FFTrees](#) for creating FFTs from and applying them to data.

```
fftrees_threshold_factor_grid
```

Perform a grid search over factor and return accuracy statistics for a given factor cue

Description

Perform a grid search over factor and return accuracy statistics for a given factor cue

Usage

```
fftrees_threshold_factor_grid(
  thresholds = NULL,
  cue_v = NULL,
  criterion_v = NULL,
  directions = "=",
  goal.threshold = NULL,
  sens.w = NULL,
  my.goal = NULL,
  my.goal.fun = NULL,
  cost.each = NULL,
  cost.outcomes = NULL
)
```

Arguments

thresholds	numeric. A vector of factor thresholds to consider.
cue_v	numeric. Feature/cue values.
criterion_v	logical. A logical vector of (TRUE) criterion values.
directions	character. Character vector of threshold directions to consider.
goal.threshold	A character string indicating the criterion to maximize when <i>optimizing cue thresholds</i> : "acc" = overall accuracy, "bacc" = balanced accuracy, "wacc" = weighted accuracy, "dprime" = discriminability, "cost" = costs (based only on cost.outcomes, as cost.cues are constant per cue). Default: goal.threshold = "bacc".
sens.w	numeric. Sensitivity weight parameter (from 0 to 1, for computing wacc). Default: sens.w = .50.
my.goal	Name of an optional, user-defined goal (as character string). Default: my.goal = NULL.
my.goal.fun	User-defined goal function (with 4 arguments hi fa mi cr). Default: my.goal.fun = NULL.
cost.each	numeric. A constant cost value to add to each value (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, in some common currency. For instance, `cost.outcomes = listc("hi" = 0, "fa" = 10, "mi" = 20, "cr" = 0)` means that a false alarm and miss cost 10 and 20 units, respectively, while correct decisions have no cost.

Value

A data frame containing accuracy statistics for factor thresholds.

See Also

[fftrees_threshold_numeric_grid](#) for numeric cues.

`fftrees_threshold_numeric_grid`

Perform a grid search over thresholds and return accuracy statistics for a given numeric cue

Description

Perform a grid search over thresholds and return accuracy statistics for a given numeric cue

Usage

```
fftrees_threshold_numeric_grid(
  thresholds,
  cue_v,
  criterion_v,
  directions = c(">", "<="),
  goal.threshold = NULL,
  sens.w = NULL,
  my.goal = NULL,
  my.goal.fun = NULL,
  cost.each = NULL,
  cost.outcomes = NULL
)
```

Arguments

<code>thresholds</code>	numeric. A vector of thresholds to consider.
<code>cue_v</code>	numeric. Feature values.
<code>criterion_v</code>	logical. A logical vector of (TRUE) criterion values.
<code>directions</code>	character. Possible directions to consider.

<code>goal.threshold</code>	A character string indicating the criterion to maximize when <i>optimizing cue thresholds</i> : "acc" = overall accuracy, "bacc" = balanced accuracy, "wacc" = weighted accuracy, "dprime" = discriminability, "cost" = costs (based only on <code>cost.outcomes</code> , as <code>cost.cues</code> are constant per cue). Default: <code>goal.threshold = "bacc"</code> .
<code>sens.w</code>	numeric. Sensitivity weight parameter (from 0 to 1, for computing <code>wacc</code>). Default: <code>sens.w = .50</code> .
<code>my.goal</code>	Name of an optional, user-defined goal (as character string). Default: <code>my.goal = NULL</code> .
<code>my.goal.fun</code>	User-defined goal function (with 4 arguments <code>hi fa mi cr</code>). Default: <code>my.goal.fun = NULL</code> .
<code>cost.each</code>	numeric. A constant cost value to add to each value (e.g., the 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, in some common currency. For instance, <code>cost.outcomes = listc("hi" = 0, "fa" = 10, "mi" = 20, "cr" = 0)</code> means that a false alarm and miss cost 10 and 20 units, respectively, while correct decisions have no cost.

Value

A data frame containing accuracy statistics for numeric thresholds.

See Also

[fftrees_threshold_factor_grid](#) for factor cues.

fftrees_wordstoftrees

Convert a verbal description of an FFT into an FFTrees object

Description

`fftrees_wordstoftrees` converts a verbal description of an FFT (provided as a string of text) into a tree definition (of an `FFTrees` object). Thus, `fftrees_wordstoftrees` provides a simple natural language parser for FFTs.

`fftrees_wordstoftrees` is the complement function to [fftrees_ffttowords](#), which converts an abstract tree definition (of an `FFTrees` object) into a verbal description (i.e., provides natural language output).

To increase robustness, the parsing of `fftrees_wordstoftrees` allows for lower- or uppercase spellings (but not typographical variants) and ignores the else-part of the final sentence (i.e., the part beginning with "otherwise").

Usage

```
fftrees_wordstoftrees(x, my.tree)
```

Arguments

x	An FFTrees object.
my.tree	A character string. A verbal description (as a string of text) defining an FFT.

Value

An FFTrees object with a new tree definition as described by my.tree.

See Also

[ffttrees_ffttowords](#) for converting FFTs into verbal descriptions; [print.FFTrees](#) for printing FFTs; [plot.FFTrees](#) for plotting FFTs; [summary.FFTrees](#) for summarizing FFTs; [FFTrees](#) for creating FFTs from and applying them to data.

flip_exits	<i>Flip exits in an FFT definition</i>
------------	--

Description

flip_exits reverses the exits of one or more nodes from an existing FFT definition (in the tidy data frame format).

flip_exits alters the value(s) of the non-final exits specified in nodes (from 0 to 1, or from 1 to 0). By contrast, exits of final nodes remain unchanged.

Duplicates in nodes are flipped only once (rather than repeatedly) and nodes not in the range 1:nrow(fft) are ignored.

flip_exits is a more specialized function than [edit_nodes](#).

Usage

```
flip_exits(fft, nodes = NA, quiet = FALSE)
```

Arguments

fft	One FFT definition (as a data frame in tidy format, with one row per node).
nodes	The FFT nodes whose exits are to be flipped (as an integer vector). Default: nodes = NA.
quiet	Hide feedback messages (as logical)? Default: quiet = FALSE.

Value

One FFT definition (as a data frame in tidy format, with one row per node).

See Also

[add_nodes](#) for adding nodes to an FFT definition; [edit_nodes](#) for editing nodes in an FFT definition; [drop_nodes](#) for deleting nodes from an FFT definition; [reorder_nodes](#) for reordering nodes of an FFT definition; [select_nodes](#) for selecting nodes in an FFT definition; [get_fft_df](#) for getting the FFT definitions of an FFTrees object; [read_fft_df](#) for reading one FFT definition from tree definitions; [add_fft_df](#) for adding FFTs to tree definitions; [FFTrees](#) for creating FFTs from and applying them to data.

Other tree definition and manipulation functions: [add_fft_df\(\)](#), [add_nodes\(\)](#), [drop_nodes\(\)](#), [edit_nodes\(\)](#), [get_fft_df\(\)](#), [read_fft_df\(\)](#), [reorder_nodes\(\)](#), [select_nodes\(\)](#), [write_fft_df\(\)](#)

 forestfires

Forest fires data

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

fire.crit *Criterion*: Was there a fire (greater than 1.00 ha)?

Values: TRUE (yes) vs. FALSE (no) (47.0% vs. 53.0%).

Details

We made the following enhancements to the original data for improved usability:

- The criterion was redefined from a numeric variable that indicated the number of hectares that burned in a fire into a logical variable (TRUE (for values >1) vs. FALSE (for values <=1)).

Other than that, the data remains consistent with the original dataset.

Source

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

Original creator: Prof. Paulo Cortez and Aníbal Morais Department of Information Systems University of Minho, Portugal

See Also

Other datasets: [blood](#), [breastcancer](#), [car](#), [contraceptive](#), [creditapproval](#), [fertility](#), [heart.cost](#), [heart.test](#), [heart.train](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [sonar](#), [titanic](#), [voting](#), [wine](#)

get_best_tree	<i>Select the best tree (from current set of FFTs)</i>
---------------	--

Description

get_best_tree selects (looks up and identifies) the best tree (as an integer) from the set (or “fan”) of FFTs contained in the current FFTrees object x, an existing type of data (‘train’ or ‘test’), and a goal for which corresponding statistics are available in the designated data type (in x\$trees\$stats).

Usage

```
get_best_tree(x, data, goal, my.goal.max = TRUE)
```

Arguments

x	An FFTrees object.
data	The type of data to consider (as character: either ‘train’ or ‘test’).
goal	A goal (as character) to be maximized or minimized when selecting a tree from an existing FFTrees object x (with existing x\$trees\$stats).
my.goal.max	Default direction for user-defined my.goal (as logical): Should my.goal be maximized? Default: my.goal.max = TRUE.

Details

Importantly, `get_best_tree` only identifies and selects the ‘tree’ *identifier* (as an integer) from the set of *existing* trees with known statistics, rather than creating new trees or computing new cue thresholds. More specifically, `goal` is used for identifying and selecting the ‘tree’ identifier (as an integer) of the best FFT from an existing set of FFTs, but not for computing new cue thresholds (see `goal.threshold` and `ffttrees_cuerank()`) or creating new trees (see `goal.chase` and `ffttrees_ranktrees()`).

Value

An integer denoting the tree that maximizes/minimizes `goal` in data.

See Also

[FFTrees](#) for creating FFTs from and applying them to data.

Other utility functions: [get_exit_type\(\)](#), [get_fft_df\(\)](#)

<code>get_exit_type</code>	<i>Get exit type (from a vector x of FFT exit descriptions)</i>
----------------------------	---

Description

`get_exit_type` checks and converts a vector `x` of FFT exit descriptions into exits of an FFT that correspond to the current options of `exit_types` (as a global constant).

Usage

```
get_exit_type(x, verify = TRUE)
```

Arguments

<code>x</code>	A vector of FFT exit descriptions.
<code>verify</code>	A flag to turn verification on/off (as logical). Default: <code>verify = TRUE</code> .

Details

`get_exit_type` also verifies that the exit types conform to an FFT (e.g., only the exits of the final node are bi-directional).

Value

A vector of `exit_types` (or an error).

See Also

[FFTrees](#) for creating FFTs from and applying them to data.

Other utility functions: [get_best_tree\(\)](#), [get_fft_df\(\)](#)

Examples

```

get_exit_type(c(0, 1, .5))
get_exit_type(c(FALSE, " True ", 2/4))
get_exit_type(c("noise", "signal", "final"))
get_exit_type(c("left", "right", "both"))

```

get_fft_df

Get FFT definitions (from an FFTrees object x)

Description

get_fft_df gets the FFT definitions of an FFTrees object x (as a data.frame).

Usage

```
get_fft_df(x)
```

Arguments

x An FFTrees object.

Details

The FFTs in the data.frame returned are represented in the one-line per FFT definition format used by an FFTrees object.

In addition to looking up x\$trees\$definitions, get_fft_df verifies that the FFT definitions are valid (given current settings).

Value

A set of FFT definitions (as a data.frame/tibble, in the one-line per FFT definition format used by an FFTrees object).

See Also

[read_fft_df](#) for reading one FFT definition from tree definitions; [write_fft_df](#) for writing one FFT to tree definitions; [add_fft_df](#) for adding FFTs to tree definitions; [FFTrees](#) for creating FFTs from and applying them to data.

Other utility functions: [get_best_tree\(\)](#), [get_exit_type\(\)](#)

Other tree definition and manipulation functions: [add_fft_df\(\)](#), [add_nodes\(\)](#), [drop_nodes\(\)](#), [edit_nodes\(\)](#), [flip_exits\(\)](#), [read_fft_df\(\)](#), [reorder_nodes\(\)](#), [select_nodes\(\)](#), [write_fft_df\(\)](#)

heart.cost	<i>Cue costs for the heartdisease data</i>
------------	--

Description

This data further characterizes the variables (cues) in the [heartdisease](#) dataset.

Usage

heart.cost

Format

A list of length 13 containing the cost of each cue in the [heartdisease](#) dataset (in dollars). Each list element is a single (positive numeric) value.

Source

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

See Also

[heartdisease](#) dataset.

Other datasets: [blood](#), [breastcancer](#), [car](#), [contraceptive](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.test](#), [heart.train](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [sonar](#), [titanic](#), [voting](#), [wine](#)

heart.test	<i>Heart disease testing data</i>
------------	-----------------------------------

Description

Testing data for a [heartdisease](#) data. This subset is 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 (see [heartdisease](#) for details).

Source

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

See Also

[heartdisease](#) dataset.

Other datasets: [blood](#), [breastcancer](#), [car](#), [contraceptive](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.train](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [sonar](#), [titanic](#), [voting](#), [wine](#)

heart.train	<i>Heart disease training data</i>
-------------	------------------------------------

Description

Training data for a binary prediction model (here: FFT) on (a subset of) the [heartdisease](#) data. The complementary subset for model testing is [heart.test](#). The data in [heartdisease](#) contains both subsets.

Usage

```
heart.train
```

Format

A data frame containing 150 rows and 14 columns (see [heartdisease](#) for details).

Source

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

See Also

[heartdisease](#) dataset.

Other datasets: [blood](#), [breastcancer](#), [car](#), [contraceptive](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [sonar](#), [titanic](#), [voting](#), [wine](#)

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

Description

A dataset predicting the diagnosis of 303 patients tested for heart disease.

Usage

```
heartdisease
```

Format

A data frame containing 303 rows and 14 columns, with the following variables:

diagnosis True value of binary criterion: TRUE = Heart disease, FALSE = No Heart disease

age Age (in years)

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" = reversible defect

Source

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

See Also

[heart.cost](#) dataset for cost information.

Other datasets: [blood](#), [breastcancer](#), [car](#), [contraceptive](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heart.train](#), [iris.v](#), [mushrooms](#), [sonar](#), [titanic](#), [voting](#), [wine](#)

inwords

Provide a verbal description of an FFT

Description

inwords generates and provides a verbal description of a fast-and-frugal tree (FFT) from an FFTrees object.

When data remains unspecified, inwords will only look up `x$trees$inwords`. When data is set to either "train" or "test", inwords first employs `ffttrees_ffttowords` to re-generate the verbal descriptions of FFTs in `x`.

Usage

```
inwords(x, data = NULL, tree = 1)
```

Arguments

<code>x</code>	An FFTrees object.
<code>data</code>	The type of data to which a tree is being applied (as character string "train" or "test"). Default: <code>data = NULL</code> will only look up <code>x\$trees\$inwords</code> .
<code>tree</code>	The tree to display (as an integer).

Value

A verbal description of an FFT (as a character string).

See Also

[ffttrees_ffttowords](#) for converting FFTs into verbal descriptions; [print.FFTrees](#) for printing FFTs; [plot.FFTrees](#) for plotting FFTs; [summary.FFTrees](#) for summarizing FFTs; [FFTrees](#) for creating FFTs from and applying them to data.

```
iris.v
```

```
Iris data
```

Description

A famous dataset from R.A. Fisher (1936) simplified to predict only the virginica class (i.e., as a binary classification problem).

Usage

```
iris.v
```

Format

A data frame containing 150 rows and 4 columns.

sep.len sepal length in cm

sep.wid sepal width in cm

pet.len petal length in cm

pet.wid petal width in cm

virginica *Criterion*: Does an iris belong to the class "virginica"?

Values: TRUE vs. FALSE (33.33% vs.66.67%).

Details

To improve usability, we made the following changes:

- The criterion was binarized from a factor variable with three levels (*Iris-setosa*, *Iris-versicolor*, *Iris-virginica*), into a logical variable (i.e., TRUE for all instances of *Iris-virginica* and FALSE for the two other levels).

Other than that, the data remains consistent with the original dataset.

Source

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

References

Fisher, R.A. (1936): The use of multiple measurements in taxonomic problems. *Annual Eugenics*, 7, Part II, pp. 179–188.

See Also

Other datasets: [blood](#), [breastcancer](#), [car](#), [contraceptive](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heart.train](#), [heartdisease](#), [mushrooms](#), [sonar](#), [titanic](#), [voting](#), [wine](#)

mushrooms

Mushrooms data

Description

Data describing poisonous vs. non-poisonous mushrooms.

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 *Criterion*: Is the mushroom poisonous?

Values: TRUE (poisonous) vs. FALSE (edible) (48.2% vs. 51.8%).

cshape cap-shape, character (bell=b, conical=c, convex=x, flat=f, knobbed=k, sunken=s)

csurface cap-surface, character (fibrous=f, grooves=g, scaly=y, smooth=s)

ccolor cap-color, character (brown=n, buff=b, cinnamon=c, gray=g, green=r, pink=p, purple=u, red=e, white=w, yellow=y)

- bruises** Are there bruises? logical (TRUE/FALSE)
- odor** character (almond=a, anise=l, creosote=c, fishy=y, foul=f, musty=m, none=n, pungent=p, spicy=s)
- gattach** gill-attachment, character (attached=a, descending=d, free=f, notched=n)
- gspace** gill-spacing, character (close=c, crowded=w, distant=d)
- gsize** gill-size, character (broad=b, narrow=n)
- gcolor** gill-color, character (black=k, brown=n, buff=b, chocolate=h, gray=g, green=r, orange=o, pink=p, purple=u, red=e, white=w, yellow=y)
- sshape** stalk-shape, character (enlarging=e, tapering=t)
- root** stalk-root, character (bulbous=b, club=c, cup=u, equal=e, rhizomorphs=z, rooted=r)
- ssaring** stalk-surface-above-ring, character (fibrous=f, scaly=y, silky=k, smooth=s)
- ssbring** stalk-surface-below-ring, character (fibrous=f, scaly=y, silky=k, smooth=s)
- scaring** stalk-color-above-ring, character (brown=n, buff=b, cinnamon=c, gray=g, orange=o, pink=p, red=e, white=w, yellow=y)
- scbring** stalk-color-below-ring, character (brown=n, buff=b, cinnamon=c, gray=g, orange=o, pink=p, red=e, white=w, yellow=y)
- vtype** veil-type, character (partial=p, universal=u)
- vcolor** veil-color, character (brown=n, orange=o, white=w, yellow=y)
- ringnum** character (none=n, one=o, two=t)
- ringtype** character (cobwebby=c, evanescent=e, flaring=f, large=l, none=n, pendant=p, sheathing=s, zone=z)
- sporepc** spore-print-color, character (black=k, brown=n, buff=b, chocolate=h, green=r, orange=o, purple=u, white=w, yellow=y)
- population** character (abundant=a, clustered=c, numerous=n, scattered=s, several=v, solitary=y)
- habitat** character (grasses=g, leaves=l, meadows=m, paths=p, urban=u, waste=w, woods=d)

Details

This dataset includes descriptions of hypothetical samples corresponding to 23 species of gilled mushrooms in the *Agaricus* and *Lepiota* Family. Each species is classified as poisonous (True or False). The Guide clearly states that there is no simple rule for determining the edibility of a mushroom; no rule like “leaflets three, let it be” for Poisonous Oak and Ivy.

We made the following enhancements to the original data for improved usability:

- Any missing values, denoted as "?" in the dataset, were transformed into NAs.
- Binary factor variables with exclusive "t" and "f" values were converted to logical TRUE/FALSE vectors.
- The binary factor *criterion* variable with exclusive "p" and "e" values was converted to a logical TRUE/FALSE vector.

Other than that, the data remains consistent with the original dataset.

Source

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

References

Mushroom records drawn from The Audubon Society Field Guide to North American Mushrooms (1981). G.H. Lincoff (Pres.), New York: A.A. Knopf.

See Also

Other datasets: [blood](#), [breastcancer](#), [car](#), [contraceptive](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heart.train](#), [heartdisease](#), [iris.v](#), [sonar](#), [titanic](#), [voting](#), [wine](#)

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

Description

plot.FFTrees visualizes an FFTrees object created by the [FFTrees](#) function.

plot.FFTrees is the main plotting function of the **FFTrees** package and called when evaluating the generic [plot](#) on an FFTrees object.

plot.FFTrees visualizes a selected FFT, key data characteristics, and various aspects of classification performance.

As x may not contain test data, plot.FFTrees by default plots the performance characteristics for training data (i.e., fitting), rather than for test data (i.e., for prediction). When test data is available, specifying data = "test" plots prediction performance.

Whenever the sensitivity weight (sens.w) is set to its default of sens.w = 0.50, a level shows *balanced* accuracy (bacc). If, however, sens.w deviates from its default, the level shows the tree's *weighted* accuracy value (wacc) and the current sens.w value (below the level).

Many aspects of the plot (e.g., its panels) and the FFT's appearance (e.g., labels of its nodes and exits) can be customized by setting corresponding arguments.

Usage

```
## S3 method for class 'FFTrees'  
plot(  
  x = NULL,  
  data = "train",  
  what = "all",  
  tree = 1,  
  main = NULL,  
  cue.labels = NULL,  
  decision.labels = NULL,  
  cue.cex = NULL,  
  threshold.cex = NULL,
```

```

decision.cex = 1,
comp = TRUE,
show.header = NULL,
show.tree = NULL,
show.confusion = NULL,
show.levels = NULL,
show.roc = NULL,
show.icons = NULL,
show.iconguide = NULL,
hlines = TRUE,
label.tree = NULL,
label.performance = NULL,
n.per.icon = NULL,
level.type = "bar",
which.tree = NULL,
decision.names = NULL,
stats = NULL,
...
)

```

Arguments

x	An FFTrees object created by the FFTrees function.
data	<p>The type of data in x to be plotted (as a string) or a test dataset (as a data frame).</p> <ul style="list-style-type: none"> • A valid data string must be either 'train' (for fitting performance) or 'test' (for prediction performance). • For a valid data frame, the specified tree is evaluated and plotted for this data (as 'test' data), but the global FFTrees object x remains unchanged unless it is re-assigned. <p>By default, data = 'train' (as x may not contain test data).</p>
what	<p>What should be plotted (as a character string)? Valid options are:</p> <ul style="list-style-type: none"> 'all' Plot the tree diagram with all corresponding guides and performance statistics, but excluding cue accuracies. 'cues' Plot only the marginal accuracy of cues in ROC space. Note that cue accuracies are <i>not</i> shown when calling what = 'all' and use the showcues function. 'icontree' Plot tree diagram with icon arrays on exit nodes. Consider also setting n.per.icon and show.iconguide. 'tree' Plot only the tree diagram. 'roc' Plot only the performance of tree(s) (and comparison algorithms) in ROC space. <p>Default: what = 'all'.</p>
tree	<p>The tree to be plotted (as an integer, only valid when the corresponding tree argument is non-empty). Default: tree = 1. To plot the best training or best test tree with respect to the goal specified during FFT construction, use 'best.train' or 'best.test', respectively.</p>

<code>main</code>	The main plot label (as a character string).
<code>cue.labels</code>	An optional string of labels for the cues / nodes (as character vector).
<code>decision.labels</code>	A character vector of length 2 indicating the content-specific names for noise and signal predictions/exits.
<code>cue.cex</code>	The size of the cue labels (as numeric).
<code>threshold.cex</code>	The size of the threshold labels (as numeric).
<code>decision.cex</code>	The size of the decision labels (as numeric).
<code>comp</code>	Should the performance of competitive algorithms (e.g.; logistic regression, random forests, etc.) be shown in the ROC plot (if available, as logical)?
<code>show.header</code>	Show header with basic data properties (in top panel, as logical)?
<code>show.tree</code>	Show nodes and exits of FFT (in middle panel, as logical)?
<code>show.confusion</code>	Show a 2x2 confusion matrix (in bottom panel, as logical)?
<code>show.levels</code>	Show performance levels (in bottom panel, as logical)?
<code>show.roc</code>	Show ROC curve (in bottom panel, as logical)?
<code>show.icons</code>	Show exit cases as icon arrays (in middle panel, as logical)?
<code>show.iconguide</code>	Show icon guide (in middle panel, as logical)?
<code>hlines</code>	Show horizontal panel separation lines (as logical)? Default: <code>hlines = TRUE</code> .
<code>label.tree</code>	A label for the FFT (optional, as character string).
<code>label.performance</code>	A label for the performance section (optional, as character string).
<code>n.per.icon</code>	The number of cases represented by each icon (as numeric).
<code>level.type</code>	The type of performance levels to be drawn at the bottom (as character string, either "bar" or "line". Default: <code>level.type = "bar"</code>).
<code>which.tree</code>	Deprecated argument. Use <code>tree</code> instead.
<code>decision.names</code>	Deprecated argument. Use <code>decision.labels</code> instead.
<code>stats</code>	Deprecated argument. Should statistical information be plotted (as logical)? Use <code>what = "all"</code> to include performance statistics and <code>what = "tree"</code> to plot only a tree diagram.
<code>...</code>	Graphical parameters (passed to text of panel titles, to <code>showcues</code> when <code>what = 'cues'</code> , or to <code>title</code> when <code>what = 'roc'</code>).

Value

An invisible FFTrees object `x` and a plot visualizing and describing an FFT (as side effect).

See Also

[showcues](#) for plotting cue accuracies; [print.FFTrees](#) for printing FFTs; [summary.FFTrees](#) for summarizing FFTs; [FFTrees](#) for creating FFTs from and applying them to data.

Other plot functions: [showcues\(\)](#)

Examples

```

# Create FFTs (for heartdisease data):
heart_fft <- FFTrees(formula = diagnosis ~ .,
                    data = heart.train)

# Visualize the default FFT (Tree #1, what = 'all'):
plot(heart_fft, main = "Heart disease",
     decision.labels = c("Absent", "Present"))

# Visualize cue accuracies (in ROC space):
plot(heart_fft, what = "cues", main = "Cue accuracies for heart disease data")

# Visualize tree diagram with icon arrays on exit nodes:
plot(heart_fft, what = "icontree", n.per.icon = 2,
     main = "Diagnosing heart disease")

# Visualize performance comparison in ROC space:
plot(heart_fft, what = "roc", main = "Performance comparison for heart disease data")

# Visualize predictions of FFT #2 (for new test data) with custom options:
plot(heart_fft, tree = 2, data = heart.test,
     main = "Predicting heart disease",
     cue.labels = c("1. thal?", "2. cp?", "3. ca?", "4. exang"),
     decision.labels = c("ok", "sick"), n.per.icon = 2,
     show.header = TRUE, show.confusion = FALSE, show.levels = FALSE, show.roc = FALSE,
     hlines = FALSE, font = 3, col = "steelblue")

# # For details, see
# vignette("FFTrees_plot", package = "FFTrees")

```

predict.FFTrees

Predict classification outcomes or probabilities from data

Description

predict.FFTrees predicts binary classification outcomes or their probabilities from newdata for an FFTrees object.

Usage

```

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

```

```

    method = "laplace",
    data = NULL,
    ...
  )

```

Arguments

object	An FFTrees object created by the FFTrees function.
newdata	dataframe. A data frame 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, "prob" which returns a matrix of class probabilities, or "both" which returns a matrix with both class and probability predictions.
sens.w, data	deprecated
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.

See Also

[print.FFTrees](#) for printing FFTs; [plot.FFTrees](#) for plotting FFTs; [summary.FFTrees](#) for summarizing FFTs; [FFTrees](#) for creating FFTs from and applying them to data.

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 object from the training data:
breast.fft <- FFTrees(
  formula = diagnosis ~ .,
  data = breast.train
)

# Predict classification outcomes for test data:
breast.fft.pred <- predict(breast.fft,
  newdata = breast.test
)

# Predict class probabilities for test data:
breast.fft.pred <- predict(breast.fft,
  newdata = breast.test,

```

```

    type = "prob"
  )

```

```
print.FFTrees
```

Print basic information of fast-and-frugal trees (FFTs)

Description

print.FFTrees prints basic information on FFTs for an FFTrees object x.

As x may not contain test data, print.FFTrees by default prints the performance characteristics for training data (i.e., fitting), rather than for test data (i.e., for prediction). When test data is available, specify data = "test" to print prediction performance.

Usage

```

## S3 method for class 'FFTrees'
print(x = NULL, tree = 1, data = "train", ...)

```

Arguments

x	An FFTrees object created by FFTrees .
tree	The tree to be printed (as an integer, only valid when the corresponding tree argument is non-empty). Default: tree = 1. To print the best training or best test tree with respect to the goal specified during FFT construction, use "best.train" or "best.test", respectively.
data	The type of data in x to be printed (as a string) or a test dataset (as a data frame). <ul style="list-style-type: none"> • A valid data string must be either 'train' (for fitting performance) or 'test' (for prediction performance). • For a valid data frame, the specified tree is evaluated and printed for this data (as 'test' data), but the global FFTrees object x remains unchanged unless it is re-assigned. <p>By default, data = 'train' (as x may not contain test data).</p>
...	additional arguments passed to print.

Value

An invisible FFTrees object x and summary information on an FFT printed to the console (as side effect).

See Also

[plot.FFTrees](#) for plotting FFTs; [summary.FFTrees](#) for summarizing FFTs; [inwords](#) for obtaining a verbal description of FFTs; [FFTrees](#) for creating FFTs from and applying them to data.

read_fft_df	<i>Read an FFT definition from tree definitions</i>
-------------	---

Description

read_fft_df reads and returns the definition of a single FFT (as a tidy data frame) from the multi-line FFT definitions of an FFTrees object.

read_fft_df allows reading individual tree definitions to manipulate them with other tree trimming functions.

[write_fft_df](#) provides the inverse functionality.

Usage

```
read_fft_df(ffts_df, tree = 1)
```

Arguments

ffts_df	A set of FFT definitions (as a data frame, usually from an FFTrees object, with suitable variable names to pass <code>verify_ffts_df</code>).
tree	The ID of the to-be-selected FFT (as an integer), corresponding to a tree in <code>ffts_df</code> . Default: <code>tree = 1</code> .

Value

One FFT definition (as a data frame in tidy format, with one row per node).

See Also

[get_fft_df](#) for getting the FFT definitions of an FFTrees object; [write_fft_df](#) for writing one FFT to tree definitions; [add_fft_df](#) for adding FFTs to tree definitions; [FFTrees](#) for creating FFTs from and applying them to data.

Other tree definition and manipulation functions: [add_fft_df\(\)](#), [add_nodes\(\)](#), [drop_nodes\(\)](#), [edit_nodes\(\)](#), [flip_exits\(\)](#), [get_fft_df\(\)](#), [reorder_nodes\(\)](#), [select_nodes\(\)](#), [write_fft_df\(\)](#)

reorder_nodes	<i>Reorder nodes in an FFT definition</i>
---------------	---

Description

reorder_nodes allows reordering the nodes in an existing FFT definition (in the tidy data frame format).

reorder_nodes allows to directly set and change the node order in an FFT definition by specifying nodes.

When a former non-final node becomes a final node, the exit type of the former final node is set to the signal value (i.e., `exit_types[2]`).

Usage

```
reorder_nodes(fft, order = NA, quiet = FALSE)
```

Arguments

fft	One FFT definition (as a data frame in tidy format, with one row per node).
order	The desired node order (as an integer vector). The values of order must be a permutation of 1:nrow(fft). Default: order = NA.
quiet	Hide feedback messages (as logical)? Default: quiet = FALSE.

Value

One FFT definition (as a data frame in tidy format, with one row per node).

See Also

[add_nodes](#) for adding nodes to an FFT definition; [edit_nodes](#) for editing nodes in an FFT definition; [drop_nodes](#) for deleting nodes from an FFT definition; [flip_exits](#) for reversing exits in an FFT definition; [select_nodes](#) for selecting nodes in an FFT definition; [get_fft_df](#) for getting the FFT definitions of an FFTrees object; [read_fft_df](#) for reading one FFT definition from tree definitions; [add_fft_df](#) for adding FFTs to tree definitions; [FFTrees](#) for creating FFTs from and applying them to data.

Other tree definition and manipulation functions: [add_fft_df\(\)](#), [add_nodes\(\)](#), [drop_nodes\(\)](#), [edit_nodes\(\)](#), [flip_exits\(\)](#), [get_fft_df\(\)](#), [read_fft_df\(\)](#), [select_nodes\(\)](#), [write_fft_df\(\)](#)

select_nodes	<i>Select nodes from an FFT definition</i>
--------------	--

Description

`select_nodes` selects one or more nodes from an existing FFT definition (by filtering the corresponding row(s) from the FFT definition in the tidy data frame format).

When not selecting the final node, the last selected node becomes the new final node (i.e., gains a second exit).

Duplicates in nodes are selected only once (rather than incrementally) and nodes not in the range 1:nrow(fft) are ignored.

`select_nodes` is the inverse function of [drop_nodes](#).

Usage

```
select_nodes(fft, nodes = NA, quiet = FALSE)
```

Arguments

<code>fft</code>	One FFT definition (as a data frame in tidy format, with one row per node).
<code>nodes</code>	The FFT nodes to select (as an integer vector). Default: <code>nodes = NA</code> .
<code>quiet</code>	Hide feedback messages (as logical)? Default: <code>quiet = FALSE</code> .

Value

One FFT definition (as a data frame in tidy format, with one row per node).

See Also

[add_nodes](#) for adding nodes to an FFT definition; [drop_nodes](#) for deleting nodes from an FFT definition; [edit_nodes](#) for editing nodes in an FFT definition; [flip_exits](#) for reversing exits in an FFT definition; [reorder_nodes](#) for reordering nodes of an FFT definition; [get_fft_df](#) for getting the FFT definitions of an FFTrees object; [read_fft_df](#) for reading one FFT definition from tree definitions; [add_fft_df](#) for adding FFTs to tree definitions; [FFTrees](#) for creating FFTs from and applying them to data.

Other tree definition and manipulation functions: [add_fft_df\(\)](#), [add_nodes\(\)](#), [drop_nodes\(\)](#), [edit_nodes\(\)](#), [flip_exits\(\)](#), [get_fft_df\(\)](#), [read_fft_df\(\)](#), [reorder_nodes\(\)](#), [write_fft_df\(\)](#)

showcues

Visualize cue accuracies (as points in ROC space)

Description

`showcues` plots the cue accuracies of an FFTrees object created by the [FFTrees](#) function (as points in ROC space).

If the optional arguments `cue.accuracy` and `alt.goal` are specified, their values take precedence over the corresponding settings of an FFTrees object `x` (but do not change `x`).

`showcues` is called when the main [plot.FFTrees](#) function is set to what = "cues".

Usage

```
showcues(
  x = NULL,
  cue.accuracy = NULL,
  alt.goal = NULL,
  main = NULL,
  top = 5,
  quiet = list(ini = TRUE, fin = FALSE, set = TRUE),
  ...
)
```

Arguments

<code>x</code>	An FFTrees object created by the FFTrees function.
<code>cue.accuracies</code>	An optional data frame specifying cue accuracies directly (without specifying FFTrees object <code>x</code>).
<code>alt.goal</code>	An optional alternative goal to sort the current cue accuracies (without using the goal of FFTrees object <code>x</code>).
<code>main</code>	A main plot title (as character string).
<code>top</code>	How many of the top cues should be highlighted (as an integer)?
<code>quiet</code>	Should user feedback messages be suppressed (as a list of 3 logical arguments)? Default: <code>quiet = list(ini = TRUE, fin = FALSE, set = FALSE)</code> .
<code>...</code>	Graphical parameters (passed to plot).

Value

A plot showing cue accuracies (of an FFTrees object) (as points in ROC space).

See Also

[print.FFTrees](#) for printing FFTs; [plot.FFTrees](#) for plotting FFTs; [summary.FFTrees](#) for summarizing FFTs; [FFTrees](#) for creating FFTs from and applying them to data.

Other plot functions: [plot.FFTrees\(\)](#)

Examples

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

# Show cue accuracies (in ROC space):
showcues(heart.fft,
         main = "Predicting heart disease")
```

sonar

Sonar data

Description

The file contains patterns of sonar signals bounced off a metal cylinder or bounced off a roughly cylindrical rock at various angles and under various conditions. The transmitted sonar signal is a frequency-modulated chirp, rising in frequency.

Usage

sonar

Format

A data frame containing 208 rows and 60 columns.

- V1** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V2** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V3** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V4** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V5** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V6** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V7** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V8** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V9** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V10** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V11** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V12** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V13** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V14** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V15** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V16** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V17** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V18** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.

- V40** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V41** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V42** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V43** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V44** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V45** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V46** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V47** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V48** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V49** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V50** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V51** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V52** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V53** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V54** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V55** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V56** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V57** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V58** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V59** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.
- V60** Number in the range 0.0 to 1.0 that represents the energy within a particular frequency band, integrated over a certain period of time.

mine.crit *Criterion:* Did a sonar signal bounce off a metal cylinder (or a rock)?

Values: TRUE (metal cylinder) vs. FALSE (rock) (53.37% vs. 46.63%).

Details

We made the following enhancements to the original data for improved usability:

- The binary factor *criterion* variable with exclusive "m" and "r" values was converted to a logical TRUE/FALSE vector.

Other than that, the data remains consistent with the original dataset.

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))

References

Gorman, R. P., and Sejnowski, T. J. (1988). "Analysis of Hidden Units in a Layered Network Trained to Classify Sonar Targets" in *Neural Networks*, Vol. 1, pp. 75-89.

See Also

Other datasets: [blood](#), [breastcancer](#), [car](#), [contraceptive](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heart.train](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [titanic](#), [voting](#), [wine](#)

summary.FFTrees	<i>Summarize an FFTrees object</i>
-----------------	------------------------------------

Description

summary.FFTrees summarizes key contents of an FFTrees object.

Usage

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

Arguments

object	An FFTrees object.
tree	The tree to summarize (as an integer, but may be a vector). If tree = NULL (as per default) or exceeding the possible range 1:object\$trees\$n, information on all trees in object is returned.
...	Additional arguments (currently ignored).

Details

Given an `FFTrees` object `x`, `summary.FFTrees` selects key parameters from `x$params` and provides the definitions and performance statistics for tree from `x$trees`. Inspect and query `x` for additional details.

`summary.FFTrees` returns an invisible list containing two elements:

1. definitions and corresponding performance measures of trees;
2. stats on decision frequencies, derived probabilities, and costs (separated by train and test).

A header prints descriptive information of the `FFTrees` object (to the console): Its main title, number of trees (`object$trees$n`), and the name of the criterion variable (`object$criterion_name`).

Per default, information on all available trees is shown and returned. Specifying `tree` filters the output list elements for the corresponding tree(s). When only a single tree is specified, the printed header includes a verbal description of the corresponding tree.

While `summary.FFTrees` provides key details about the specified tree(s), the individual decisions (stored in `object$trees$decisions`) are not shown or returned.

Value

An invisible list with elements containing the definitions and performance stats of the FFT(s) specified by `tree(s)`.

See Also

[print.FFTrees](#) for printing FFTs; [plot.FFTrees](#) for plotting FFTs; [inwords](#) for obtaining a verbal description of FFTs; [FFTrees](#) for creating FFTs from and applying them to data.

titanic

Titanic survival data

Description

Data 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 Logical - Whether the passenger survived (TRUE) or not (FALSE)

Details

See [Titanic](#) of the R **datasets** package for details and the same data (in a 4-dimensional table).

Source

<https://www.encyclopedia-titanica.org>

References

Dawson, Robert J. MacG. (1995), The 'Unusual Episode' Data Revisited. *Journal of Statistics Education*, 3. doi: 10.1080/10691898.1995.11910499.

See Also

Other datasets: [blood](#), [breastcancer](#), [car](#), [contraceptive](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heart.train](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [sonar](#), [voting](#), [wine](#)

voting

Voting data

Description

A dataset of votes for each of the U.S. House of Representatives Congressmen on the 16 key votes identified by the CQA.

Usage

voting

Format

A data frame containing 435 rows and 16 columns.

handicapped handicapped-infants, logical (TRUE, FALSE)

water water-project-cost-sharing, logical (TRUE, FALSE)

adoption adoption-of-the-budget-resolution, logical (TRUE, FALSE)

physician physician-fee-freeze, logical (TRUE, FALSE)

elsalvador el-salvador-aid, logical (TRUE, FALSE)

religionschool religious-groups-in-schools, logical (TRUE, FALSE)

satellite anti-satellite-test-ban, logical (TRUE, FALSE)

nicaraguan aid-to-nicaraguan-contras, logical (TRUE, FALSE)

mxmissile mxmissile, logical (TRUE, FALSE)

immigration immigration, logical (TRUE, FALSE)

synfuels synfuels-corporation-cutback, logical (TRUE, FALSE)

education education-spending, logical (TRUE, FALSE)

superfund superfund-right-to-sue, logical (TRUE, FALSE)

crime crime, logical (TRUE, FALSE)

dutyfree duty-free-exports, logical (TRUE, FALSE)

southafrica export-administration-act-south-africa, logical (TRUE, FALSE)

party.crit *Criterion*: Where the voters democratic (or republican) congressmen?

Values: TRUE (democrat) / FALSE (republican) (61.52% vs. 38.48%).

Details

The CQA lists nine different types of votes: voted for, paired for, and announced for (these three simplified to yea), voted against, paired against, and announced against (these three simplified to nay), voted present, voted present to avoid conflict of interest, and did not vote or otherwise make a position known (these three simplified to an unknown disposition).

We made the following enhancements to the original data for improved usability:

- Any missing values, denoted as "?" in the dataset, were transformed into NAs.
- Binary factor variables with exclusive "y" and "n" values were converted to logical TRUE/FALSE vectors.
- The binary character *criterion* variable with exclusive "democrat" and "republican" values was converted to a logical TRUE/FALSE vector.

Other than that, the data remains consistent with the original dataset.

Source

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

References

Congressional Quarterly Almanac, 98th Congress, 2nd session 1984, Volume XL: Congressional Quarterly Inc. Washington, D.C., 1985.

See Also

Other datasets: [blood](#), [breastcancer](#), [car](#), [contraceptive](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heart.train](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [sonar](#), [titanic](#), [wine](#)

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

Description

Chemical and tasting data from wines in North Portugal.

Usage

wine

Format

A data frame containing 6497 rows and 13 columns.

fixed.acidity fixed acidity (numeric)

volatile.acidity volatile acidity (numeric)

citric.acid citric acid (numeric)

residual.sugar residual sugar (numeric)

chlorides chlorides (numeric)

free.sulfur.dioxide free sulfur dioxide (numeric)

total.sulfur.dioxide total sulfur dioxide (numeric)

density density (numeric)

pH PH Value (numeric)

sulphates Sulphates (numeric)

alcohol Alcohol (numeric)

quality Quality (numeric, score between 0 and 10)

type *Criterion*: Is the wine red or white? (24.61% vs.75.39%)

Source

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

References

P. Cortez, A. Cerdeira, F. Almeida, T. Matos and J. Reis. Modeling wine preferences by data mining from physicochemical properties. In Decision Support Systems, *Elsevier*, 47(4):547-553. ISSN: 0167-9236.

See Also

Other datasets: [blood](#), [breastcancer](#), [car](#), [contraceptive](#), [creditapproval](#), [fertility](#), [forestfires](#), [heart.cost](#), [heart.test](#), [heart.train](#), [heartdisease](#), [iris.v](#), [mushrooms](#), [sonar](#), [titanic](#), [voting](#)

write_fft_df	<i>Write an FFT definition to tree definitions</i>
--------------	--

Description

`write_fft_df` writes the definition of a single FFT (as a tidy data frame) into the one-line FFT definition used by an `FFTrees` object.

`write_fft_df` allows turning individual tree definitions into the one-line FFT definition format used by an `FFTrees` object.

[read_fft_df](#) provides the inverse functionality.

Usage

```
write_fft_df(fft, tree = -99L)
```

Arguments

<code>fft</code>	One FFT definition (as a data frame in tidy format, with one row per node).
<code>tree</code>	The ID of the to-be-written FFT (as an integer). Default: <code>tree = -99L</code> .

Value

An FFT definition in the one line FFT definition format used by an `FFTrees` object (as a data frame).

See Also

[get_fft_df](#) for getting the FFT definitions of an `FFTrees` object; [read_fft_df](#) for reading one FFT definition from tree definitions; [add_fft_df](#) for adding FFTs to tree definitions; [FFTrees](#) for creating FFTs from and applying them to data.

Other tree definition and manipulation functions: [add_fft_df\(\)](#), [add_nodes\(\)](#), [drop_nodes\(\)](#), [edit_nodes\(\)](#), [flip_exits\(\)](#), [get_fft_df\(\)](#), [read_fft_df\(\)](#), [reorder_nodes\(\)](#), [select_nodes\(\)](#)

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