Package ‘ingredients’

April 10, 2021

Title Effects and Importances of Model Ingredients

Version 2.2.0

Description Collection of tools for assessment of feature importance and feature effects.

Key functions are:
feature_importance() for assessment of global level feature importance,
ceteris_paribus() for calculation of the what-if plots,
partial_dependence() for partial dependence plots,
conditional_dependence() for conditional dependence plots,
accumulated_dependence() for accumulated local effects plots,
aggregate_profiles() and cluster_profiles() for aggregation of ceteris paribus profiles,
generic print() and plot() for better usability of selected explainers,
generic plotD3() for interactive, D3 based explanations, and
generic describe() for explanations in natural language.

The package 'ingredients' is a part of the 'DrWhy.AI’ universe (Biecek 2018) <arXiv:1806.08915>.

Depends R (>= 3.5)

License GPL-3

Encoding UTF-8

RoxygenNote 7.1.1

Imports ggplot2, scales, gridExtra, methods

Suggests DALEX, gower, ranger, testthat, r2d3, jsonlite, knitr, markdown, covr

URL https://ModelOriented.github.io/ingredients/,
    https://github.com/ModelOriented/ingredients

BugReports https://github.com/ModelOriented/ingredients/issues

VignetteBuilder knitr

NeedsCompilation no

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Accumulated Local Effects Profiles aka ALEPlots

**Description**

Accumulated Local Effects Profiles accumulate local changes in Ceteris Paribus Profiles. Function `accumulated_dependence` calls `ceteris_paribus` and then `aggregate_profiles`. 
Usage

accumulated_dependence(x, ...)

## S3 method for class 'explainer'
accumulated_dependence(
  x,
  variables = NULL,
  N = 500,
  variable_splits = NULL,
  grid_points = 101,
  ...,
  variable_type = "numerical"
)

## Default S3 method:
accumulated_dependence(
  x,
  data,
  predict_function = predict,
  label = class(x)[1],
  variables = NULL,
  N = 500,
  variable_splits = NULL,
  grid_points = 101,
  ...,
  variable_type = "numerical"
)

## S3 method for class 'ceteris_paribus_explainer'
accumulated_dependence(x, ..., variables = NULL)

accumulated_dependency(x, ...)

Arguments

x an explainer created with function DALEX::explain(), an object of the class ceteris_paribus_explainer or a model to be explained.

... other parameters

variables names of variables for which profiles shall be calculated. Will be passed to calculate_variable_split. If NULL then all variables from the validation data will be used.

N number of observations used for calculation of partial dependence profiles. By default, 500 observations will be chosen randomly.

variable_splits named list of splits for variables, in most cases created with calculate_variable_split. If NULL then it will be calculated based on validation data avaliable in the explainer.

grid_points number of points for profile. Will be passed to calculate_variable_split.
accumulated_dependence

variable_type a character. If "numerical" then only numerical variables will be calculated. If "categorical" then only categorical variables will be calculated.

data validation dataset Will be extracted from x if it’s an explainer NOTE: It is best when target variable is not present in the data

predict_function predict function Will be extracted from x if it’s an explainer

label name of the model. By default it’s extracted from the class attribute of the model

Details
Find more details in the Accumulated Local Dependence Chapter.

Value
an object of the class aggregated_profiles_explainer

References

Examples
library("DALEX")
library("ingredients")

model_titanic_glm <- glm(survived ~ gender + age + fare, 
                          data = titanic_imputed, family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm, 
                                data = titanic_imputed[-8], 
                                y = titanic_imputed[,8], 
                                verbose = FALSE)

adp_glm <- accumulated_dependence(explain_titanic_glm, 
                                    N = 25, variables = c("age", "fare"))

head(adp_glm)
plot(adp_glm)

library("ranger")

model_titanic_rf <- ranger(survived ~., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf, 
                               data = titanic_imputed[-8], 
                               y = titanic_imputed[,8], 
                               label = "ranger forest", 
                               verbose = FALSE)
aggregate_profiles

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adp_rf <- accumulated_dependence(explain_titanic_rf, N = 200, variable_type = "numerical") plot(adp_rf)

adp_rf <- accumulated_dependence(explain_titanic_rf, N = 200, variable_type = "categorical") plotD3(adp_rf, label_margin = 80, scale_plot = TRUE)

aggregate_profiles  Aggregates Ceteris Paribus Profiles

Description

The function `aggregate_profiles()` calculates an aggregate of ceteris paribus profiles. It can be: Partial Dependence Profile (average across Ceteris Paribus Profiles), Conditional Dependence Profile (local weighted average across Ceteris Paribus Profiles) or Accumulated Local Dependence Profile (cumulated average local changes in Ceteris Paribus Profiles).

Usage

```r
aggregate_profiles(
  x,
  ..., variable_type = "numerical",
  groups = NULL,
  type = "partial",
  variables = NULL,
  span = 0.25,
  center = FALSE
)
```

Arguments

- **x** a ceteris paribus explainer produced with function `ceteris_paribus()`
- **...** other explainers that shall be calculated together
- **variable_type** a character. If numerical then only numerical variables will be calculated. If categorical then only categorical variables will be calculated.
- **groups** a variable name that will be used for grouping. By default NULL which means that no groups shall be calculated
- **type** either partial/conditional/accumulated for partial dependence, conditional profiles of accumulated local effects
- **variables** if not NULL then aggregate only for selected variables will be calculated
- **span** smoothing coefficient, by default 0.25. It's the sd for gaussian kernel
- **center** by default accumulated profiles start at 0. If center=TRUE, then they are centered around mean prediction, which is calculated on the observations used in ceteris_paribus.
Value
an object of the class aggregated_profiles_explainer

References

Examples
library("DALEX")
library("ingredients")
library("ranger")
head(titanic_imputed)

model_titanic_rf <- ranger(survived ~., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf, 
 data = titanic_imputed[,-8], 
 y = titanic_imputed[,8], 
 label = "ranger forest", 
 verbose = FALSE)

selected_passangers <- select_sample(titanic_imputed, n = 100)
cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passangers)
head(cp_rf)

# continuous variable
pdp_rf_p <- aggregate_profiles(cp_rf, variables = "age", type = "partial")
pdp_rf_p$`_label_` <- "RF_partial"
pdp_rf_c <- aggregate_profiles(cp_rf, variables = "age", type = "conditional")
pdp_rf_c$`_label_` <- "RF_conditional"
pdp_rf_a <- aggregate_profiles(cp_rf, variables = "age", type = "accumulated")
pdp_rf_a$`_label_` <- "RF_accumulated"

plot(pdp_rf_p, pdp_rf_c, pdp_rf_a, color = "_label_")
pdp_rf <- aggregate_profiles(cp_rf, variables = "age", 
 groups = "gender")
head(pdp_rf)
plot(cp_rf, variables = "age") +
 show_observations(cp_rf, variables = "age") +
 show_rugs(cp_rf, variables = "age", color = "red") +
 show_aggregated_profiles(pdp_rf, size = 3, color = "_label_")

# categorical variable
pdp_rf_p <- aggregate_profiles(cp_rf, variables = "class", 
 variable_type = "categorical", type = "partial")
pdp_rf_p$`_label_` <- "RF_partial"
pdp_rf_c <- aggregate_profiles(cp_rf, variables = "class", 
 variable_type = "categorical", type = "conditional")
pdp_rf_c$'_label_` <- "RF_conditional"
pdp_rf_a <- aggregate_profiles(cp_rf, variables = "class",
    variable_type = "categorical", type = "accumulated")
pdp_rf_a$'_label_` <- "RF_accumulated"
plot(pdp_rf_p, pdp_rf_c, pdp_rf_a, color = "_label_")

# or maybe flipped?
library(ggplot2)
plot(pdp_rf_p, pdp_rf_c, pdp_rf_a, color = "_label_") + coord_flip()

pdp_rf <- aggregate_profiles(cp_rf, variables = "class", variable_type = "categorical",
    groups = "gender")
head(pdp_rf)
plot(pdp_rf, variables = "class")
# or maybe flipped?
plot(pdp_rf, variables = "class") + coord_flip()

bind_plots

Bind Multiple ggplot Objects

Description
This is an aesthetically efficient implementation of the grid.arrange

Usage
bind_plots(..., byrow = FALSE)

Arguments
...
byrow

Value
(gtable) A plottable object with plot().

Author(s)
https://github.com/harell
Examples

```r
library("DALEX")
library("ingredients")

titanic_glm <- glm(survived ~ gender + age + fare,
                    data = titanic_imputed, family = "binomial")

explain_glm <- explain(titanic_glm,
                        data = titanic_imputed,
                        y = titanic_imputed$survived,
                        verbose = FALSE)

pdp_numerical <- partial_dependence(explain_glm, N = 50, variable_type = "numerical")
pdp_categorical <- partial_dependence(explain_glm, N = 50, variable_type = "categorical")

# Bind plots by rows
bind_plots(plot(pdp_numerical), plot(pdp_categorical), byrow = TRUE)

# Bind plots by columns
bind_plots(plot(pdp_numerical), plot(pdp_categorical), byrow = FALSE)
```

---

**calculate_oscillations**

*Calculate Oscillations for Ceteris Paribus Explainer*

**Description**

Oscillations are proxies for local feature importance at the instance level. Find more details in the Ceteris Paribus Oscillations Chapter.

**Usage**

```r
calculate_oscillations(x, sort = TRUE, ...)
```

**Arguments**

- `x`: a ceteris paribus explainer produced with the `ceteris_paribus()` function
- `sort`: a logical value. If TRUE then rows are sorted along the oscillations
- `...`: other arguments

**Value**

an object of the class `ceteris_paribus_oscillations`
References


Examples

library("DALEX")
library("ingredients")
titanic_small <- select_sample(titanic_imputed, n = 500, seed = 1313)

# build a model
model_titanic_glm <- glm(survived ~ gender + age + fare,
data = titanic_small, family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
data = titanic_small[, -8],
y = titanic_small[, 8])

cp_rf <- ceteris_paribus(explain_titanic_glm, titanic_small[1,])
calculate_oscillations(cp_rf)

library("ranger")

apartments_rf_model <- ranger(m2.price ~ construction.year + surface + floor +
no.rooms + district, data = apartments)

explainer_rf <- explain(apartments_rf_model,
data = apartments_test[, -1],
y = apartments_test$m2.price,
label = "ranger forest",
verbose = FALSE)
apartment <- apartments_test[1,]
cp_rf <- ceteris_paribus(explainer_rf, apartment)
calculate_oscillations(cp_rf)

---

calculate_variable_profile

*Internal Function for Individual Variable Profiles*

Description

This function calculates individual variable profiles (ceteris paribus profiles), i.e. series of predictions from a model calculated for observations with altered single coordinate.
calculate_variable_profile

Usage

calculate_variable_profile(
  data,
  variable_splits,
  model,
  predict_function = predict,
  ...
)

## Default S3 method:
calculate_variable_profile(
  data,
  variable_splits,
  model,
  predict_function = predict,
  ...
)

Arguments

data set of observations. Profile will be calculated for every observation (every row)
variable_splits named list of vectors. Elements of the list are vectors with points in which
profiles should be calculated. See an example for more details.
model a model that will be passed to the predict_function
predict_function function that takes data and model and returns numeric predictions. Note that
the ... arguments will be passed to this function.
...
other parameters that will be passed to the predict_function

Details

Note that calculate_variable_profile function is S3 generic. If you want to work on non
standard data sources (like H2O ddf, external databases) you should overload it.

Value

a data frame with profiles for selected variables and selected observations

References

drwhy.ai/
calculate_variable_split

Internal Function for Split Points for Selected Variables

Description

This function calculate candidate splits for each selected variable. For numerical variables splits are calculated as percentiles (in general uniform quantiles of the length grid_points). For all other variables splits are calculated as unique values.

Usage

```r
calculate_variable_split(
  data,
  variables = colnames(data),
  grid_points = 101,
  variable_splits_type = "quantiles",
  new_observation = NA
)
```

## Default S3 method:
```r
calculate_variable_split(
  data,
  variables = colnames(data),
  grid_points = 101,
  variable_splits_type = "quantiles",
  new_observation = NA
)
```

Arguments

- `data`: validation dataset. Is used to determine distribution of observations.
- `variables`: names of variables for which splits shall be calculated
- `grid_points`: number of points used for response path
- `variable_splits_type`: how variable grids shall be calculated? Use "quantiles" (default) for percentiles or "uniform" to get uniform grid of points
- `new_observation`: if specified (not NA) then all values in `new_observation` will be included in `variable_splits`

Details

Note that `calculate_variable_split` function is S3 generic. If you want to work on non standard data sources (like H2O ddf, external databases) you should overload it.
**Value**

A named list with splits for selected variables

---

**ceteris_paribus**  
*Ceteris Paribus Profiles aka Individual Variable Profiles*

---

**Description**

This explainer works for individual observations. For each observation it calculates Ceteris Paribus Profiles for selected variables. Such profiles can be used to hypothesize about model results if selected variable is changed. For this reason it is also called 'What-If Profiles'.

**Usage**

ceteris_paribus(x, ...)

```r
## S3 method for class 'explainer'
ceteris_paribus(
  x,
  new_observation,
  y = NULL,
  variables = NULL,
  variable_splits = NULL,
  grid_points = 101,
  variable_splits_type = "quantiles",
  ...
)
```

```r
## Default S3 method:
ceteris_paribus(
  x,
  data,
  predict_function = predict,
  new_observation,
  y = NULL,
  variables = NULL,
  variable_splits = NULL,
  grid_points = 101,
  variable_splits_type = "quantiles",
  variable_splits_with_obs = FALSE,
  label = class(x)[1],
  ...
)
```
ceteris_paribus

Arguments

- **x**: an explainer created with the DALEX::explain() function, or a model to be explained.
- **...**: other parameters
- **new_observation**: a new observation with columns that corresponds to variables used in the model
- **y**: true labels for `new_observation`. If specified then will be added to ceteris paribus plots. NOTE: It is best when target variable is not present in the `new_observation`
- **variables**: names of variables for which profiles shall be calculated. Will be passed to `calculate_variable_split`. If NULL then all variables from the validation data will be used.
- **variable_splits**: named list of splits for variables, in most cases created with `calculate_variable_split`. If NULL then it will be calculated based on validation data available in the explainer.
- **grid_points**: maximum number of points for profile calculations. Note that the final number of points may be lower than `grid_points`, eg. if there is not enough unique values for a given variable. Will be passed to `calculate_variable_split`.
- **variable_splits_type**: how variable grids shall be calculated? Use "quantiles" (default) for percentiles or "uniform" to get uniform grid of points
- **data**: validation dataset. It will be extracted from x if it's an explainer. NOTE: It is best when target variable is not present in the data
- **predict_function**: predict function. It will be extracted from x if it's an explainer
- **variable_splits_with_obs**: if TRUE then all values in `new_observation` will be included in `variable_splits`
- **label**: name of the model. By default it's extracted from the class attribute of the model

Details

Find more details in Ceteris Paribus Chapter.

Value

an object of the class `ceteris_paribus_explainer`.

References

Examples

```r
library("DALEX")
library("ingredients")
titanic_small <- select_sample(titanic_imputed, n = 500, seed = 1313)

# build a model
model_titanic_glm <- glm(survived ~ gender + age + fare,
                          data = titanic_small,
                          family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
                                data = titanic_small[,-8],
                                y = titanic_small[,8])

cp_rf <- ceteris_paribus(explain_titanic_glm, titanic_small[1,])
cp_rf

plot(cp_rf, variables = "age")

library("ranger")
model_titanic_rf <- ranger(survived ~., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf,
                               data = titanic_imputed[,-8],
                               y = titanic_imputed[,8],
                               label = "ranger forest",
                               verbose = FALSE)

# select few passangers
selected_passangers <- select_sample(titanic_imputed, n = 20)
cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passangers)
cp_rf

plot(cp_rf, variables = "age") +
     show_observations(cp_rf, variables = "age") +
     show_rugs(cp_rf, variables = "age", color = "red")
```

---

**Ceteris Paribus 2D Plot**

**Description**

This function calculates ceteris paribus profiles for grid of values spanned by two variables. It may be useful to identify or present interactions between two variables.
Usage

ceteris_paribus_2d(explainer, observation, grid_points = 101, variables = NULL)

Arguments

explainer          a model to be explained, preprocessed by the DALEX::explain() function
observation        a new observation for which predictions need to be explained
grid_points        number of points used for response path. Will be used for both variables
variables          if specified, then only these variables will be explained

Value

an object of the class ceteris_paribus_2d_explainer.

References


Examples

library("DALEX")
library("ingredients")

model_titanic_glm <- glm(survived ~ age + fare,
                          data = titanic_imputed, family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
                                data = titanic_imputed[,-8],
                                y = titanic_imputed[,8])

cp_rf <- ceteris_paribus_2d(explain_titanic_glm, titanic_imputed[1,],
                            variables = c("age", "fare", "sibsp"))

head(cp_rf)

plot(cp_rf)

library("ranger")
set.seed(59)

apartments_rf_model <- ranger(m2.price ~., data = apartments)

explainer_rf <- explain(apartments_rf_model,
                         data = apartments_test[,-1],
                         y = apartments_test[,1],
                         label = "ranger forest",
                         verbose = FALSE)

new_apartment <- apartments_test[1,]
cluster_profiles

new_apartment

wi_rf_2d <- ceteris_paribus_2d(explainer_rf, observation = new_apartment,
                                 variables = c("surface", "floor", "no.rooms"))

head(wi_rf_2d)
plot(wi_rf_2d)

---

cluster_profiles

Description

This function calculates aggregates of ceteris paribus profiles based on hierarchical clustering.

Usage

cluster_profiles(
  x,
  ...,
  aggregate_function = mean,
  variable_type = "numerical",
  center = FALSE,
  k = 3,
  variables = NULL
)

Arguments

x a ceteris paribus explainer produced with function ceteris_paribus()

... other explainers that shall be plotted together

aggregate_function a function for profile aggregation. By default it’s mean

variable_type a character. If numerical then only numerical variables will be computed. If
categorical then only categorical variables will be computed.

center shall profiles be centered before clustering

k number of clusters for the hclust function

variables if not NULL then only variables will be presented

Details

Find more details in the Clustering Profiles Chapter.

Value

an object of the class aggregated_profiles_explainer
References


Examples

```r
library("DALEX")
library("ingredients")

selected_passangers <- select_sample(titanic_imputed, n = 100)
model_titanic_glm <- glm(survived ~ gender + age + fare,
                         data = titanic_imputed, family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
                               data = titanic_imputed[, -8],
                               y = titanic_imputed[,8])

cp_rf <- ceteris_paribus(explain_titanic_glm, selected_passangers)
clust_rf <- cluster_profiles(cp_rf, k = 3, variables = "age")
plot(clust_rf)

library("ranger")
model_titanic_rf <- ranger(survived ~ ., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf,
                              data = titanic_imputed[, -8],
                              y = titanic_imputed[,8],
                              label = "ranger forest",
                              verbose = FALSE)

cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passangers)

plot(cp_rf, color = "grey", variables = "age")
```

```r
plot(cp_rf, color = "grey", variables = "age") +
    show_aggregated_profiles(clust_rf, color = "_label_", size = 2)

clust_rf <- cluster_profiles(cp_rf, k = 3, center = TRUE, variables = "age")
head(clust_rf)
```
### Conditional Dependence Profiles

Conditional Dependence Profiles (aka Local Profiles) average locally Ceteris Paribus Profiles. Function `conditional_dependence` calls `ceteris_paribus` and then `aggregate_profiles`.

#### Usage

```r
conditional_dependence(x, ...)
```

#### S3 method for class 'explainer'

```r
conditional_dependence(
  x,
  variables = NULL,
  N = 500,
  variable_splits = NULL,
  grid_points = 101,
  ..., variable_type = "numerical"
)
```

#### Default S3 method:

```r
conditional_dependence(
  x,
  data,
  predict_function = predict,
  label = class(x)[1],
  variables = NULL,
  N = 500,
  variable_splits = NULL,
  grid_points = 101,
  ..., variable_type = "numerical"
)
```

#### S3 method for class 'ceteris_paribus_explainer'

```r
conditional_dependence(x, ..., variables = NULL)
```

`local_dependency(x, ...)`

`conditional_dependency(x, ...)`
Arguments

- **x**: an explainer created with function `DALEX::explain()`, an object of the class `ceteris_paribus_explainer` or a model to be explained.
- **...**: other parameters
- **variables**: names of variables for which profiles shall be calculated. Will be passed to `calculate_variable_split`. If `NULL` then all variables from the validation data will be used.
- **N**: number of observations used for calculation of partial dependence profiles. By default 500.
- **variable_splits**: named list of splits for variables, in most cases created with `calculate_variable_split`. If `NULL` then it will be calculated based on validation data available in the explainer.
- **grid_points**: number of points for profile. Will be passed to `calculate_variable_split`.
- **variable_type**: a character. If "numerical" then only numerical variables will be calculated. If "categorical" then only categorical variables will be calculated.
- **data**: validation dataset, will be extracted from x if it's an explainer. NOTE: It is best when target variable is not present in the data
- **predict_function**: predict function, will be extracted from x if it's an explainer
- **label**: name of the model. By default it's extracted from the class attribute of the model

Details

Find more details in the Accumulated Local Dependence Chapter.

Value

an object of the class `aggregated_profile_explainer`

References


Examples

```r
library("DALEX")
library("ingredients")

model_titanic_glm <- glm(survived ~ gender + age + fare,
                          data = titanic_imputed, family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
                                data = titanic_imputed[, -8],
                                y = titanic_imputed[, 8],
                                verbose = FALSE)
```
cdp_glm <- conditional_dependence(explain_titanic_glm, 
    N = 150, variables = c("age", "fare"))
head(cdp_glm)
plot(cdp_glm)

library("ranger")
model_titanic_rf <- ranger(survived ~., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf, 
    data = titanic_imputed[,-8],
    y = titanic_imputed[,8],
    label = "ranger forest",
    verbose = FALSE)

cdp_rf <- conditional_dependence(explain_titanic_rf, N = 200, variable_type = "numerical")
plot(cdp_rf)

cdp_rf <- conditional_dependence(explain_titanic_rf, N = 200, variable_type = "categorical")
plotD3(cdp_rf, label_margin = 100, scale_plot = TRUE)

### describe.partial_dependence_explainer

*Natural language description of feature importance explainer*

**Description**

Generic function `describe` generates a natural language description of `ceteris_paribus()`, `aggregated_profiles()` and `feature_importance()` explanations what enchaces their interpretability.

**Usage**

```r
# S3 method for class 'partial_dependence_explainer'
describe(
    x,
    nonsignificance_treshold = 0.15,
    ..., 
    display_values = FALSE, 
    display_numbers = FALSE, 
    variables = NULL, 
    label = "prediction"
)
```

describe(x, ...)
## S3 method for class 'ceteris_paribus_explainer'
```r
describe(
    x,
    nonsignificance_treshold = 0.15,
    ..., display_values = FALSE,
    display_numbers = FALSE,
    variables = NULL,
    label = "prediction"
)
```

## S3 method for class 'feature_importance_explainer'
```r
describe(x, nonsignificance_treshold = 0.15, ...)
```

### Arguments
- **x**: a ceteris paribus explanation produced with function `ceteris_paribus()`
- **nonsignificance_treshold**: a parameter specifying a threshold for variable importance
- **...**: other arguments
- **display_values**: allows for displaying variable values
- **display_numbers**: allows for displaying numerical values
- **variables**: a character of a single variable name to be described
- **label**: label for model’s prediction

### Details
Function `describe.ceteris_paribus()` generates a natural language description of ceteris paribus profile. The description summarizes variable values, that would change model’s prediction at most. If a ceteris paribus profile for multiple variables is passed, variables must specify a single variable to be described. Works only for a ceteris paribus profile for one observation. In current version only categorical values are described. For `display_numbers = TRUE` three most important variable values are displayed, while `display_numbers = FALSE` displays all the important variables, however without further details.

Function `describe.feature_importance_explainer()` generates a natural language description of feature importance explanation. It prints the number of important variables, that have significant dropout difference from the full model, depending on `nonsignificance_treshold`. The description prints the three most important variables for the model’s prediction. The current design of DALEX explainer does not allow for displaying variables values.
References

Examples

library("DALEX")
library("ingredients")
library("ranger")

model_titanic_rf <- ranger(survived ~., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf,
    data = titanic_imputed[, -8],
    y = titanic_imputed[, 8],
    label = "ranger forest",
    verbose = FALSE)

selected_passagers <- select_sample(titanic_imputed, n = 10)
cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passagers)
pdp <- aggregate_profiles(cp_rf, type = "partial", variable_type = "categorical")
describe(pdp, variables = "gender")

library("DALEX")
library("ingredients")
library("ranger")

model_titanic_rf <- ranger(survived ~., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf,
    data = titanic_imputed[, -8],
    y = titanic_imputed[, 8],
    label = "ranger forest",
    verbose = FALSE)

selected_passanger <- select_sample(titanic_imputed, n = 1, seed = 123)
cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passanger)

plot(cp_rf, variable_type = "categorical")
describe(cp_rf, variables = "class", label = "the predicted probability")

library("DALEX")
library("ingredients")

lm_model <- lm(m2.price ~ ., data = apartments)
explainer_lm <- explain(lm_model, data = apartments[, -1], y = apartments[, 1])

fi_lm <- feature_importance(explainer_lm, loss_function = DALEX::loss_root_mean_square)
**Description**

This function calculates permutation based feature importance. For this reason it is also called the Variable Dropout Plot.

**Usage**

```r
feature_importance(x, ...)  
## S3 method for class 'explainer'
feature_importance(
  x,
  loss_function = DALEX::loss_root_mean_square,
  ...,  
  type = c("raw", "ratio", "difference"),
  n_sample = NULL,
  B = 10,
  variables = NULL,
  variable_groups = NULL,
  N = n_sample,
  label = NULL
)

## Default S3 method:
feature_importance(
  x,
  data,
  y,
  predict_function = predict,
  loss_function = DALEX::loss_root_mean_square,
  ...,  
  label = class(x)[1],
  type = c("raw", "ratio", "difference"),
  n_sample = NULL,
  B = 10,
  variables = NULL,
  N = n_sample,
  variable_groups = NULL
)```

```
Arguments

- **x**: an explainer created with function `DALEX::explain()`, or a model to be explained.
- **...**: other parameters
- **loss_function**: a function that will be used to assess variable importance
- **type**: character, type of transformation that should be applied for dropout loss. "raw" results raw drop losses, "ratio" returns `drop_loss/drop_loss_full_model` while "difference" returns `drop_loss - drop_loss_full_model`
- **n_sample**: alias for `N` held for backwards compatibility. number of observations that should be sampled for calculation of variable importance.
- **B**: integer, number of permutation rounds to perform on each variable. By default it's 10.
- **variables**: vector of variables. If `NULL` then variable importance will be tested for each variable from the data separately. By default `NULL`
- **variable_groups**: list of variables names vectors. This is for testing joint variable importance. If `NULL` then variable importance will be tested separately for variables. By default `NULL`. If specified then it will override variables
- **N**: number of observations that should be sampled for calculation of variable importance. If `NULL` then variable importance will be calculated on whole dataset (no sampling).
- **label**: name of the model. By default it's extracted from the class attribute of the model
- **data**: validation dataset, will be extracted from `x` if it's an explainer NOTE: It is best when target variable is not present in the data
- **y**: true labels for data, will be extracted from `x` if it's an explainer
- **predict_function**: predict function, will be extracted from `x` if it's an explainer

Details

Find more details in the Feature Importance Chapter.

Value

an object of the class `feature_importance`

References

Examples

library("DALEX")
library("ingredients")

model_titanic_glm <- glm(survived ~ gender + age + fare,
                         data = titanic_imputed, family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
                                data = titanic_imputed[,-8],
                                y = titanic_imputed[,8])

fi_glm <- feature_importance(explain_titanic_glm, B = 1)
plot(fi_glm)

fi_glm_joint1 <- feature_importance(explain_titanic_glm,
                                     variable_groups = list("demographics" = c("gender", "age"),
                                                           "ticket_type" = c("fare")),
                                     label = "lm 2 groups")
plot(fi_glm_joint1)

fi_glm_joint2 <- feature_importance(explain_titanic_glm,
                                     variable_groups = list("demographics" = c("gender", "age"),
                                                           "wealth" = c("fare", "class"),
                                                           "family" = c("sibsp", "parch"),
                                                           "embarked" = "embarked"),
                                     label = "lm 5 groups")
plot(fi_glm_joint2, fi_glm_joint1)

library("ranger")
model_titanic_rf <- ranger(survived ~., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf,
                               data = titanic_imputed[,-8],
                               y = titanic_imputed[,8],
                               label = "ranger forest",
                               verbose = FALSE)

fi_rf <- feature_importance(explain_titanic_rf)
plot(fi_rf)

fi_rf <- feature_importance(explain_titanic_rf, B = 6) # 6 replications
plot(fi_rf)

fi_rf_group <- feature_importance(explain_titanic_rf,
                                   variable_groups = list("demographics" = c("gender", "age"),
                                                          "wealth" = c("fare", "class"),
                                                          "family" = c("sibsp", "parch"),
                                                          "embarked" = "embarked"),
                                   label = "ranger forest")
plot(fi_rf_group)
plot(fi_rf_group, fi_rf)

HR_rf_model <- ranger(status ~ ., data = HR, probability = TRUE)
explainer_rf <- explain(HR_rf_model, data = HR, y = HR$status,
                        model_info = list(type = "multiclass"))

fi_rf <- feature_importance(explainer_rf, type = "raw",
                              loss_function = DALEX::loss_cross_entropy)
head(fi_rf)
plot(fi_rf)

HR_glm_model <- glm(status == "fired" ~ ., data = HR, family = "binomial")
explainer_glm <- explain(HR_glm_model, data = HR, y = as.numeric(HR$status == "fired"))
fi_glm <- feature_importance(explainer_glm, type = "raw",
                              loss_function = DALEX::loss_root_mean_square)
head(fi_glm)
plot(fi_glm)

---

**partial_dependence**  
**Partial Dependence Profiles**

**Description**

Partial Dependence Profiles are averages from Ceteris Paribus Profiles. Function `partial_dependence` calls `ceteris_paribus` and then `aggregate_profiles`.

**Usage**

```r
partial_dependence(x, ...)
```

## S3 method for class 'explainer'
partial_dependence(
  x,
  variables = NULL,
  N = 500,
  variable_splits = NULL,
  grid_points = 101,
  ...,
  variable_type = "numerical"
)

## Default S3 method:
partial_dependence(  
x,
```
partial_dependence

```r
data,
predict_function = predict,
label = class(x)[1],
variables = NULL,
grid_points = 101,
variable_splits = NULL,
N = 500,
...
variable_type = "numerical"
)

## S3 method for class 'ceteris_paribus_explainer'
partial_dependence(x, ..., variables = NULL)

partial_dependency(x, ...)
```

**Arguments**

- **x**: an explainer created with function DALEX::explain(), an object of the class ceteris_paribus_explainer or a model to be explained.
- **...**: other parameters
- **variables**: names of variables for which profiles shall be calculated. Will be passed to calculate_variable_split. If NULL then all variables from the validation data will be used.
- **N**: number of observations used for calculation of partial dependence profiles. By default 500.
- **variable_splits**: named list of splits for variables, in most cases created with calculate_variable_split. If NULL then it will be calculated based on validation data available in the explainer.
- **grid_points**: number of points for profile. Will be passed to calculate_variable_split.
- **variable_type**: a character. If "numerical" then only numerical variables will be calculated. If "categorical" then only categorical variables will be calculated.
- **data**: validation dataset, will be extracted from x if it’s an explainer NOTE: It is best when target variable is not present in the data
- **predict_function**: predict function, will be extracted from x if it’s an explainer
- **label**: name of the model. By default it’s extracted from the class attribute of the model

**Details**

Find more details in the Partial Dependence Profiles Chapter.

**Value**

an object of the class aggregated_profiles_explainer
plot.aggregated_profiles_explainer

Plots Aggregated Profiles

Description

Function plot.aggregated_profiles_explainer plots partial dependence plot or accumulated effect plot. It works in a similar way to plot.ceteris_paribus, but instead of individual profiles show average profiles for each variable listed in the variables vector.
Usage

```r
## S3 method for class 'aggregated_profiles_explainer'
plot(
  x,
  ...,
  size = 1,
  alpha = 1,
  color = "_label_",
  facet_ncol = NULL,
  variables = NULL,
  title = NULL,
  subtitle = NULL
)
```

Arguments

- `x` a ceteris paribus explainer produced with function `aggregate_profiles()`
- `...` other explainers that shall be plotted together
- `size` a numeric. Size of lines to be plotted
- `alpha` a numeric between 0 and 1. Opacity of lines
- `color` a character. Either name of a color, or hex code for a color, or `_label_` if models shall be colored, or `_ids_` if instances shall be colored
- `facet_ncol` number of columns for the `facet_wrap`
- `variables` if not `NULL` then only variables will be presented
- `title` a character. Partial and accumulated dependence explainers have deafult value.
- `subtitle` a character. If `NULL` value will be dependent on model usage.

Value

a ggplot2 object

References


Examples

```r
library("DALEX")
library("ingredients")

model_titanic_glm <- glm(survived ~ gender + age + fare,
                          data = titanic_imputed, family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
                               data = titanic_imputed[,-8],
                               y = titanic_imputed[,8],
                               ...)
```
verbose = FALSE)

pdp_rf_p <- partial_dependence(explain_titanic_glm, N = 50)
pdp_rf_p$\_label_ <- "RF\_partial"
pdp_rf_l <- conditional_dependence(explain_titanic_glm, N = 50)
pdp_rf_l$\_label_ <- "RF\_local"
pdp_rf_a <- accumulated_dependence(explain_titanic_glm, N = 50)
pdp_rf_a$\_label_ <- "RF\_accumulated"
head(pdp_rf_p)
plot(pdp_rf_p, pdp_rf_l, pdp_rf_a, color = "\_label_")

library("ranger")

model_titanic_rf <- ranger(survived ~., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf,
data = titanic_imputed[, -8],
y = titanic_imputed[, 8],
label = "ranger forest",
verbose = FALSE)

selected_passangers <- select_sample(titanic_imputed, n = 100)
cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passangers)
cp_rf

pdp_rf_p <- aggregate_profiles(cp_rf, variables = "age", type = "partial")
pdp_rf_p$\_label_ <- "RF\_partial"
pdp_rf_c <- aggregate_profiles(cp_rf, variables = "age", type = "conditional")
pdp_rf_c$\_label_ <- "RF\_conditional"
pdp_rf_a <- aggregate_profiles(cp_rf, variables = "age", type = "accumulated")
pdp_rf_a$\_label_ <- "RF\_accumulated"

head(pdp_rf_p)
plot(pdp_rf_p)
plot(pdp_rf_p, pdp_rf_c, pdp_rf_a)

plot(cp_rf, variables = "age") +
  show_observations(cp_rf, variables = "age") +
  show_rugs(cp_rf, variables = "age", color = "red") +
  show_aggregated_profiles(pdp_rf_p, size = 2)
Description

This function plots What-If Plots for a single prediction / observation.

Usage

```r
## S3 method for class 'ceteris_paribus_2d_explainer'
plot(
  x, 
  ..., 
  facet_ncol = NULL, 
  add_raster = TRUE, 
  add_contour = TRUE, 
  bins = 3, 
  add_observation = TRUE, 
  pch = "+", 
  size = 6
)
```

Arguments

- `x`: a ceteris paribus explainer produced with the `ceteris_paribus_2d()` function
- `...`: currently will be ignored
- `facet_ncol`: number of columns for the `facet_wrap`
- `add_raster`: if TRUE then `geom_raster` will be added to present levels with diverging colors
- `add_contour`: if TRUE then `geom_contour` will be added to present contours
- `bins`: number of contours to be added
- `add_observation`: if TRUE then `geom_point` will be added to present observation that is explained
- `pch`: character, symbol used to plot observations
- `size`: numeric, size of individual datapoints

Value

A `ggplot2` object

References


Examples

```r
library("DALEX")
library("ingredients")
library("ranger")
```
apartments_rf_model <- ranger(m2.price ~ ., data = apartments)

explainer_rf <- explain(apartments_rf_model,
    data = apartments_test[,-1],
    y = apartments_test[,1],
    verbose = FALSE)

new_apartment <- apartments_test[1,]
new_apartment

wi_rf_2d <- ceteris_paribus_2d(explainer_rf, observation = new_apartment)
head(wi_rf_2d)

plot(wi_rf_2d)
plot(wi_rf_2d, add_contour = FALSE)
plot(wi_rf_2d, add_observation = FALSE)
plot(wi_rf_2d, add_raster = FALSE)

# HR data
model <- ranger(status ~ gender + age + hours + evaluation + salary, data = HR,
    probability = TRUE)
pred1 <- function(m, x) predict(m, x)$predictions[,1]

explainer_rf_fired <- explain(model,
    data = HR[,1:5],
    y = as.numeric(HR$status == "fired"),
    predict_function = pred1,
    label = "fired")

new_emp <- HR[1,]
new_emp

wi_rf_2d <- ceteris_paribus_2d(explainer_rf_fired, observation = new_emp)
head(wi_rf_2d)

plot(wi_rf_2d)

------------------------------------------------------------------
plot.ceteris_paribus_explainer
Plots Ceteris Paribus Profiles

Description

Function plot.ceteris_paribus_explainer plots Individual Variable Profiles for selected observations. Various parameters help to decide what should be plotted, profiles, aggregated profiles, points or rugs.

Find more details in Ceteris Paribus Chapter.
Usage

```r
## S3 method for class 'ceteris_paribus_explainer'
plot(
    x,
    ..., size = 1, alpha = 1, color = "#46bac2",
    variable_type = "numerical",
    facet_ncol = NULL, variables = NULL,
    title = "Ceteris Paribus profile",
    subtitle = NULL,
    categorical_type = "profiles"
)
```

Arguments

- `x`: a ceteris paribus explainer produced with function `ceteris_paribus()`
- `...`: other explainers that shall be plotted together
- `size`: a numeric. Size of lines to be plotted
- `alpha`: a numeric between 0 and 1. Opacity of lines
- `color`: a character. Either name of a color or name of a variable that should be used for coloring
- `variable_type`: a character. If `numerical` then only numerical variables will be plotted. If `categorical` then only categorical variables will be plotted.
- `facet_ncol`: number of columns for the `facet_wrap`
- `variables`: if not `NULL` then only variables will be presented
- `title`: a character. Plot title. By default "Ceteris Paribus profile".
- `subtitle`: a character. Plot subtitle. By default `NULL` - then subtitle is set to "created for the XXX, YYY model", where XXX, YYY are labels of given explainers.
- `categorical_type`: a character. How categorical variables shall be plotted? Either "profiles" (default) or "bars" or "lines".

Value

- a `ggplot2` object

References

Examples

library("DALEX")

model_titanic_glm <- glm(survived ~ gender + age + fare,
                         data = titanic_imputed, family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
                               data = titanic_imputed[,-8],
                               y = titanic_imputed[,8],
                               verbose = FALSE)

cp_glm <- ceteris_paribus(explain_titanic_glm, titanic_imputed[1,])

plot(cp_glm, variables = "age")

library("ranger")

model_titanic_rf <- ranger(survived ~., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf,
                               data = titanic_imputed[,-8],
                               y = titanic_imputed[,8],
                               label = "ranger forest",
                               verbose = FALSE)

selected_passangers <- select_sample(titanic_imputed, n = 100)

cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passangers)

cp_rf

plot(cp_rf, variables = "age") +
     show_observations(cp_rf, variables = "age") +
     show_rugs(cp_rf, variables = "age", color = "red")

selected_passangers <- select_sample(titanic_imputed, n = 1)

selected_passangers

cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passangers)

plot(cp_rf) +
     show_observations(cp_rf)

plot(cp_rf, variables = "age") +
     show_observations(cp_rf, variables = "age")

plot(cp_rf, variables = "class")
plot(cp_rf, variables = c("class", "embarked"), facet_ncol = 1)
plot(cp_rf, variables = c("class", "embarked"), facet_ncol = 1, categorical_type = "bars")
plotD3(cp_rf, variables = c("class", "embarked", "gender"),
       variable_type = "categorical", scale_plot = TRUE,
       label_margin = 70)
plot.ceteris_paribus_oscillations

*Plot Ceteris Paribus Oscillations*

**Description**
This function plots local variable importance plots calculated as oscillations in the Ceteris Paribus Profiles.

**Usage**
```r
## S3 method for class 'ceteris_paribus_oscillations'
plot(x, ..., bar_width = 10)
```

**Arguments**
- `x`: a ceteris paribus oscillation explainer produced with function `calculate_oscillations()`
- `...`: other explainers that shall be plotted together
- `bar_width`: width of bars. By default 10.

**Value**
a `ggplot2` object

**References**

**Examples**
```r
library("DALEX")
library("ranger")

apartments_rf_model <- ranger(m2.price ~., data = apartments)

explainer_rf <- explain(apartments_rf_model,
                         data = apartments_test[,-1],
                         y = apartments_test[,1],
                         label = "ranger forest",
                         verbose = FALSE)

apartment <- apartments_test[1:2,]

cp_rf <- ceteris_paribus(explainer_rf, apartment)
```
plot(feature_importance_explainer)

Plots Feature Importance

Description

This function plots variable importance calculated as changes in the loss function after variable drops. It uses output from feature_importance function that corresponds to permutation based measure of variable importance. Variables are sorted in the same order in all panels. The order depends on the average drop out loss. In different panels variable contributions may not look like sorted if variable importance is different in different in different models.

Usage

## S3 method for class 'feature_importance_explainer'
plot(
  x,
  ...,
  max_vars = NULL,
  show_boxplots = TRUE,
  bar_width = 10,
  desc_sorting = TRUE,
  title = "Feature Importance",
  subtitle = NULL
)

Arguments

x a feature importance explainer produced with the feature_importance() function
...
other explainers that shall be plotted together
max_vars maximum number of variables that shall be presented for for each model. By default NULL what means all variables
show_boxplots logical if TRUE (default) boxplot will be plotted to show permutation data.
bar_width width of bars. By default 10
desc_sorting logical. Should the bars be sorted descending? By default TRUE
title the plot's title, by default 'Feature Importance'
subtitle the plot's subtitle. By default - NULL, which means the subtitle will be 'created for the XXX model', where XXX is the label of explainer(s)
Details

Find more details in the Feature Importance Chapter.

Value

a ggplot2 object

References


Examples

library("DALEX")
library("ingredients")

model_titanic_glm <- glm(survived ~ gender + age + fare,
  data = titanic_imputed, family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
  data = titanic_imputed[,-8],
  y = titanic_imputed[,8])

fi_rf <- feature_importance(explain_titanic_glm, B = 1)
plot(fi_rf)

library("ranger")
model_titanic_rf <- ranger(survived ~., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf,
  data = titanic_imputed[,-8],
  y = titanic_imputed[,8],
  label = "ranger forest",
  verbose = FALSE)

fi_rf <- feature_importance(explain_titanic_rf)
plot(fi_rf)

HR_rf_model <- ranger(status~., data = HR, probability = TRUE)

explainer_rf <- explain(HR_rf_model, data = HR, y = HR$status,
  verbose = FALSE, precalculate = FALSE)

fi_rf <- feature_importance(explainer_rf, type = "raw", max_vars = 3,
  loss_function = DALEX::loss_cross_entropy)
head(fi_rf)
plot(fi_rf)

HR_glm_model <- glm(status == "fired"~., data = HR, family = "binomial")
explainer_glm <- explain(HR_glm_model, data = HR, y = as.numeric(HR$status == "fired"))
fi_glm <- feature_importance(explainer_glm, type = "raw",
                           loss_function = DALEX::loss_root_mean_square)

head(fi_glm)

plot(fi_glm)

---

plotD3

*Plots Ceteris Paribus Profiles in D3 with r2d3 Package.*

**Description**

Function `plotD3.ceteris_paribus_explainer` plots Individual Variable Profiles for selected observations. It uses output from `ceteris_paribus` function. Various parameters help to decide what should be plotted, profiles, aggregated profiles, points or rugs.

Find more details in Ceteris Paribus Chapter.

**Usage**

```r
plotD3(x, ..., size = 2, alpha = 1, color = "#46bac2", variable_type = "numerical", facet_ncol = 2, scale_plot = FALSE, variables = NULL, chart_title = "Ceteris Paribus Profiles", label_margin = 60, show_observations = TRUE, show_rugs = TRUE)
```

**Arguments**

- `x` a ceteris paribus explainer produced with function `ceteris_paribus()`
- `...` other explainers that shall be plotted together
- `size` a numeric. Set width of lines
- `alpha` a numeric between 0 and 1. Opacity of lines
- `color` a character. Set line color
variable_type  a character. If "numerical" then only numerical variables will be plotted. If "categorical" then only categorical variables will be plotted.

facet_ncol  number of columns for the facet_wrap

scale_plot  a logical. If TRUE, the height of plot scales with window size. By default it's FALSE

variables  if not NULL then only variables will be presented

chart_title  a character. Set custom title

label_margin  a numeric. Set width of label margins in categorical type

show_observations  a logical. Adds observations layer to a plot. By default it's TRUE

show_rugs  a logical. Adds rugs layer to a plot. By default it's TRUE

Value

a r2d3 object.

References


Examples

library("DALEX")
library("ingredients")
library("ranger")

model_titanic_rf <- ranger(survived ~ ., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf,
data = titanic_imputed[,-8],
y = titanic_imputed[,8],
label = "ranger forest",
verbose = FALSE)

selected_passangers <- select_sample(titanic_imputed, n = 10)
cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passangers)

plotD3(cp_rf, variables = c("age","parch","fare","sibsp"),
      facet_ncol = 2, scale_plot = TRUE)

selected_passanger <- select_sample(titanic_imputed, n = 1)
cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passanger)

plotD3(cp_rf, variables = c("class", "embarked", "gender", "sibsp"),
      facet_ncol = 2, variable_type = "categorical", label_margin = 100, scale_plot = TRUE)
plotD3.aggregated_profiles_explainer

Plots Aggregated Ceteris Paribus Profiles in D3 with r2d3 Package.

Description

Function `plotD3.aggregated_profiles_explainer` plots an aggregate of ceteris paribus profiles. It works in a similar way to `plotD3.ceteris_paribus_explainer` but, instead of individual profiles, show average profiles for each variable listed in the `variables` vector.

Find more details in Ceteris Paribus Chapter.

Usage

```r
## S3 method for class 'aggregated_profiles_explainer'
plotD3(
  x,
  ..., size = 2,
  alpha = 1,
  color = "#46bac2",
  facet_ncol = 2,
  scale_plot = FALSE,
  variables = NULL,
  chart_title = "Aggregated Profiles",
  label_margin = 60
)
```

Arguments

- **x**: a aggregated profiles explainer produced with function `aggregate_profiles()`
- **...**: other explainers that shall be plotted together
- **size**: a numeric. Set width of lines
- **alpha**: a numeric between 0 and 1. Opacity of lines
- **color**: a character. Set line/bar color
- **facet_ncol**: number of columns for the `facet_wrap`
- **scale_plot**: a logical. If TRUE, the height of plot scales with window size. By default it’s FALSE
- **variables**: if not NULL then only variables will be presented
- **chart_title**: a character. Set custom title
- **label_margin**: a numeric. Set width of label margins in categorical type

Value

- a r2d3 object.
plotD3.feature_importance_explainer

References


Examples

library("DALEX")
library("ingredients")
library("ranger")

# smaller data, quicker example
titanic_small <- select_sample(titanic_imputed, n = 500, seed = 1313)

# build a model
model_titanic_rf <- ranger(survived ~., data = titanic_small, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf,
data = titanic_small[-8],
y = titanic_small[,8],
label = "ranger forest",
verbose = FALSE)

selected_passangers <- select_sample(titanic_small, n = 100)
cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passangers)

pdp_rf_p <- aggregate_profiles(cp_rf, type = "partial", variable_type = "numerical")
pdp_rf_p$label_ <- "RF_partial"
pdp_rf_c <- aggregate_profiles(cp_rf, type = "conditional", variable_type = "numerical")
pdp_rf_c$label_ <- "RF_conditional"
pdp_rf_a <- aggregate_profiles(cp_rf, type = "accumulated", variable_type = "numerical")
pdp_rf_a$label_ <- "RF_accumulated"

plotD3(pdp_rf_p, pdp_rf_c, pdp_rf_a, scale_plot = TRUE)

pdp <- aggregate_profiles(cp_rf, type = "partial", variable_type = "categorical")
pdp$label_ <- "RF_partial"

plotD3(pdp, variables = c("gender","class"), label_margin = 70)

plotD3.feature_importance_explainer

Plot Feature Importance Objects in D3 with r2d3 Package.

Description

Function plotD3.feature_importance_explainer plots dropouts for variables used in the model. It uses output from feature_importance function that corresponds to permutation based measure
of feature importance. Variables are sorted in the same order in all panels. The order depends on the average drop out loss. In different panels variable contributions may not look like sorted if variable importance is different in different models.

Usage

```r
## S3 method for class 'feature_importance_explainer'
plotD3(
  x,
  \ldots,
  max_vars = NULL,
  show_boxplots = TRUE,
  bar_width = 12,
  split = "model",
  scale_height = FALSE,
  margin = 0.15,
  chart_title = "Feature importance"
)
```

Arguments

- `x` a feature importance explainer produced with the `feature_importance()` function
- `\ldots` other explainers that shall be plotted together
- `max_vars` maximum number of variables that shall be presented for each model. By default `NULL` which means all variables
- `show_boxplots` logical if `TRUE` (default) boxplot will be plotted to show permutation data.
- `bar_width` width of bars in px. By default 12px
- `split` either "model" or "feature" determines the plot layout
- `scale_height` a logical. If `TRUE`, the height of plot scales with window size. By default it's `FALSE`
- `margin` extend x axis domain range to adjust the plot. Usually value between 0.1 and 0.3, by default it's 0.15
- `chart_title` a character. Set custom title

Value

- a `r2d3` object.

References

print.aggregated_profiles_explainer

Examples

```r
library("DALEX")
library("ingredients")

lm_model <- lm(m2.price ~., data = apartments)
explainer_lm <- explain(lm_model,
  data = apartments[-1],
  y = apartments[,1],
  verbose = FALSE)

fi_lm <- feature_importance(explainer_lm,
  loss_function = DALEX::loss_root_mean_square, B = 1)
head(fi_lm)
plotD3(fi_lm)

library("ranger")

rf_model <- ranger(m2.price~., data = apartments)
explainer_rf <- explain(rf_model,
  data = apartments[-1],
  y = apartments[,1],
  label = "ranger forest",
  verbose = FALSE)

fi_rf <- feature_importance(explainer_rf, loss_function = DALEX::loss_root_mean_square)
head(fi_rf)
plotD3(fi_lm, fi_rf)
plotD3(fi_lm, fi_rf, split = "feature")
plotD3(fi_lm, fi_rf, max_vars = 3, bar_width = 16, scale_height = TRUE)
plotD3(fi_lm, fi_rf, max_vars = 3, bar_width = 16, split = "feature", scale_height = TRUE)
plotD3(fi_lm, margin = 0.2)
```

print.aggregated_profiles_explainer

Prints Aggregated Profiles

Description

Prints Aggregated Profiles
**Usage**

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

**Arguments**

- `x` an individual variable profile explainer produced with the `aggregate_profiles()` function
- `...` other arguments that will be passed to `head()`

**Examples**

```r
library("DALEX")
library("ingredients")

model_titanic_glm <- glm(survived ~ gender + age + fare, 
  data = titanic_imputed, family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm, 
  data = titanic_imputed[,-8], 
  y = titanic_imputed[,8])

selected_passangers <- select_sample(titanic_imputed, n = 100)

cp_rf <- ceteris_paribus(explain_titanic_glm, selected_passangers)

head(cp_rf)

pdp_rf <- aggregate_profiles(cp_rf, variables = "age")

head(pdp_rf)

library("ranger")

model_titanic_rf <- ranger(survived ~., data = titanic_imputed, 
  probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf, 
  data = titanic_imputed[,-8], 
  y = titanic_imputed[,8], 
  label = "ranger forest", 
  verbose = FALSE)

cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passangers)

head(cp_rf)

pdp_rf <- aggregate_profiles(cp_rf, variables = "age")

head(pdp_rf)
```
print.ceteris_paribus_explainer

Prints Individual Variable Explainer Summary

Description

Prints Individual Variable Explainer Summary

Usage

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

Arguments

- `x`: an individual variable profile explainer produced with the `ceteris_paribus()` function
- `...`: other arguments that will be passed to `head()`

Examples

```r
library("DALEX")
library("ingredients")
titanic_small <- select_sample(titanic_imputed, n = 500, seed = 1313)

# build a model
model_titanic_glm <- glm(survived ~ gender + age + fare,
data = titanic_small,
family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
data = titanic_small[-8],
y = titanic_small[,8])

cp_glm <- ceteris_paribus(explain_titanic_glm, titanic_small[1,])
cp_glm

library("ranger")

apartments_rf_model <- ranger(m2.price ~., data = apartments)

explainer_rf <- explain(apartments_rf_model,
data = apartments_test[-1],
y = apartments_test[,1],
label = "ranger forest",
verbose = FALSE)

apartments_small <- select_sample(apartments_test, 10)
```
print.feature_importance_explainer

Description
Print Generic for Feature Importance Object

Usage

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

Arguments

x an explanation created with feature_importance
...
other parameters.

Value

a data frame.

References


Examples

library("DALEX")
library("ingredients")

model_titanic_glm <- glm(survived ~ gender + age + fare,
                          data = titanic_imputed, family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
                                data = titanic_imputed[, -8],
                                y = titanic_imputed[, 8],
                                verbose = FALSE)

fi_glm <- feature_importance(explain_titanic_glm)

fi_glm
**select_neighbours**  
*Select Subset of Rows Closest to a Specified Observation*

**Description**

Function `select_neighbours` selects subset of rows from data set. This is useful if data is large and we need just a sample to calculate profiles.

**Usage**

```r
select_neighbours(
  observation,
  data,
  variables = NULL,
  distance = gower::gower_dist,
  n = 20,
  frac = NULL
)
```

**Arguments**

- `observation`: single observation
- `data`: set of observations
- `variables`: names of variables that shall be used for calculation of distance. By default these are all variables present in data and observation
- `distance`: the distance function, by default the `gower_dist()` function.
- `n`: number of neighbors to select
- `frac`: if `n` is not specified (NULL), then will be calculated as `frac` * number of rows in data. Either `n` or `frac` need to be specified.

**Details**

Note that `select_neighbours()` function is S3 generic. If you want to work on non standard data sources (like H2O ddf, external databases) you should overload it.

**Value**

a data frame with selected rows

**Examples**

```r
library("ingredients")

new_apartment <- DALEX::apartments[1,]
small_apartments <- select_neighbours(new_apartment, DALEX::apartments_test, n = 10)
```
### select_sample

**Description**

Function `select_sample` selects subset of rows from data set. This is useful if data is large and we need just a sample to calculate profiles.

**Usage**

```r
select_sample(data, n = 100, seed = 1313)
```

**Arguments**

- `data`: set of observations. Profile will be calculated for every observation (every row)
- `n`: number of observations to select.
- `seed`: seed for random number generator.

**Details**

Note that `select_subsample()` function is S3 generic. If you want to work on non standard data sources (like H2O ddf, external databases) you should overload it.

**Value**

a data frame with selected rows

**Examples**

```r
library("ingredients")

small_apartments <- select_sample(DALEX::apartments_test)
head(small_apartments)
```
**show_aggregated_profiles**

*Adds a Layer with Aggregated Profiles*

**Description**

Function `show_aggregated_profiles` adds a layer to a plot created with `plot.ceteris_paribus_explainer`.

**Usage**

```r
show_aggregated_profiles(
  x,
  ..., 
  size = 0.5,
  alpha = 1,
  color = "#371ea3",
  variables = NULL
)
```

**Arguments**

- `x` a ceteris paribus explainer produced with function `ceteris_paribus()`
- `...` other explainers that shall be plotted together
- `size` a numeric. Size of lines to be plotted
- `alpha` a numeric between 0 and 1. Opacity of lines
- `color` a character. Either name of a color or name of a variable that should be used for coloring
- `variables` if not NULL then only variables will be presented

**Value**

a ggplot2 layer

**References**


**Examples**

```r
library("DALEX")
library("ingredients")

selected_passangers <- select_sample(titanic_imputed, n = 100)

model_titanic_glm <- glm(survived ~ gender + age + fare,
```
show_observations

```
data = titanic_imputed, family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
    data = titanic_imputed[,8],
y = titanic_imputed[,8])

cp_rf <- ceteris_paribus(explain_titanic_glm, selected_passangers)

pdp_rf <- aggregate_profiles(cp_rf, type = "partial", variables = "age")

plot(cp_rf, variables = "age") +
  show_observations(cp_rf, variables = "age") +
  show_aggregated_profiles(pdp_rf, size = 3)

library("ranger")

model_titanic_rf <- ranger(survived ~., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf,
    data = titanic_imputed[,8],
y = titanic_imputed[,8],
    label = "ranger forest",
    verbose = FALSE)

cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passangers)
cp_rf

pdp_rf <- aggregate_profiles(cp_rf, type = "partial", variables = "age")
head(pdp_rf)

plot(cp_rf, variables = "age") +
  show_observations(cp_rf, variables = "age") +
  show_rugs(cp_rf, variables = "age", color = "red") +
  show_aggregated_profiles(pdp_rf, size = 3)
```

descrition

Function **show_observations** adds a layer to a plot created with `plot.ceteris_paribus_explainer` for selected observations. Various parameters help to decide what should be plotted, profiles, aggregated profiles, points or rugs.

**Usage**

```
show_observations(
```
show_observations

```r
x, 
..., 
size = 2, 
alpha = 1, 
color = "#371ea3", 
variable_type = "numerical", 
variables = NULL
)
```

**Arguments**

- **x**
  - a ceteris paribus explainer produced with function `ceteris_paribus()`
- **...**
  - other explainers that shall be plotted together
- **size**
  - a numeric. Size of lines to be plotted
- **alpha**
  - a numeric between 0 and 1. Opacity of lines
- **color**
  - a character. Either name of a color or name of a variable that should be used for coloring
- **variable_type**
  - a character. If numerical then only numerical variables will be plotted. If categorical then only categorical variables will be plotted.
- **variables**
  - if not NULL then only variables will be presented

**Value**

- a ggplot2 layer

**References**


**Examples**

```r
code
library("DALEX")
library("ingredients")
library("ranger")

rf_model <- ranger(survived ~ ., data = titanic_imputed, probability = TRUE)

explainer_rf <- explain(rf_model, 
                          data = titanic_imputed[,-8], 
                          y = titanic_imputed[,8], 
                          label = "ranger forest", 
                          verbose = FALSE)

selected_passangers <- select_sample(titanic_imputed, n = 100)

cp_rf <- ceteris_paribus(explainer_rf, selected_passangers)
cp_rf
```
show_profiles

plot(cp_rf, variables = "age", color = "grey") +
show_observations(cp_rf, variables = "age", color = "black") +
show_rugs(cp_rf, variables = "age", color = "red")

show_profiles Adds a Layer with Profiles

Description

Function `show_profiles` adds a layer to a plot created with `plot.ceteris_paribus_explainer`.

Usage

```r
show_profiles(
  x,
  ..., size = 0.5,
  alpha = 1,
  color = "#371ea3",
  variables = NULL
)
```

Arguments

- `x` a ceteris paribus explainer produced with function `ceteris_paribus()`
- `...` other explainers that shall be plotted together
- `size` a numeric. Size of lines to be plotted
- `alpha` a numeric between 0 and 1. Opacity of lines
- `color` a character. Either name of a color or name of a variable that should be used for coloring
- `variables` if not NULL then only variables will be presented

Value

a ggplot2 layer

References

**Examples**

```r
library("DALEX")
library("ingredients")

selected_passangers <- select_sample(titanic_imputed, n = 100)
selected_john <- titanic_imputed[1,]

model_titanic_glm <- glm(survived ~ gender + age + fare,
                          data = titanic_imputed, family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
                               data = titanic_imputed[,-8],
                               y = titanic_imputed[,8],
                               label = "glm", verbose = FALSE)

cp_rf <- ceteris_paribus(explain_titanic_glm, selected_passangers)
cp_rf_john <- ceteris_paribus(explain_titanic_glm, selected_john)
plot(cp_rf, variables = "age") +
     show_profiles(cp_rf_john, variables = "age", size = 2)

library("ranger")

model_titanic_rf <- ranger(survived ~., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf,
                              data = titanic_imputed[,-8],
                              y = titanic_imputed[,8],
                              label = "ranger forest",
                              verbose = FALSE)

cp_rf <- ceteris_paribus(explain_titanic_rf, selected_passangers)
cp_rf_john <- ceteris_paribus(explain_titanic_rf, selected_john)

plot(cp_rf, variables = "age") +
     show_observations(cp_rf, variables = "age") +
     show_rugs(cp_rf, variables = "age", color = "red") +
     show_profiles(cp_rf_john, variables = "age", color = "red", size = 2)
```

---

**show_residuals**

*Adds a Layer with Residuals to a Profile Plot*
Description

Function `show_residuals` adds a layer to a plot created with `plot.ceteris_paribus_explainer` for selected observations. Note that the `y` argument has to be specified in the `ceteris_paribus` function.

Usage

```r
description <- function(show_residuals(x, ..., size = 0.75, alpha = 1, color = c(`TRUE` = "#8bdcbe", `FALSE` = "#f05a71"), variables = NULL))
```

Arguments

- `x`: a ceteris paribus explainer produced with function `ceteris_paribus()`. Note that `y` parameter shall be supplied in this function.
- `...`: other explainers that shall be plotted together
- `size`: a numeric. Size of lines to be plotted
- `alpha`: a numeric between 0 and 1. Opacity of lines
- `color`: a character. Either name of a color or name of a variable that should be used for coloring
- `variables`: if not NULL then only variables will be presented

Value

A `ggplot2` layer

References


Examples

```r
library("DALEX")
library("ingredients")
library("ranger")

johny_d <- data.frame(
  class = factor("1st", levels = c("1st", "2nd", "3rd", "deck crew", "engineering crew", "restaurant staff", "victualling crew")),
  gender = factor("male", levels = c("female", "male")),
  age = 8,
  sibsp = 0,
```
show_rugs

parch = 0,
fare = 72,
embarked = factor("Southampton", levels = c("Belfast", "Cherbourg", "Queenstown", "Southampton"))
)

model_titanic_rf <- ranger(survived ~ ., data = titanic_imputed, probability = TRUE)

explain_titanic_rf <- explain(model_titanic_rf,
data = titanic_imputed[,-8],
y = titanic_imputed[,8],
label = "ranger forest",
verbose = FALSE)

johny_neighbours <- select_neighbours(data = titanic_imputed,
observation = johny_d,
variables = c("age", "gender", "class",
              "fare", "sibsp", "parch"),
n = 10)

cp_neighbours <- ceteris_paribus(explain_titanic_rf,
johny_neighbours,
y = johny_neighbours$survived == "yes",
variable_splits = list(age = seq(0,70, length.out = 1000)))

plot(cp_neighbours, variables = "age") +
show_observations(cp_neighbours, variables = "age")


cp_johny <- ceteris_paribus(explain_titanic_rf, johny_d,
variable_splits = list(age = seq(0,70, length.out = 1000)))

plot(cp_johny, variables = "age", size = 1.5, color = "#8bdce5") +
show_profiles(cp_neighbours, variables = "age", color = "#ceced9") +
show_observations(cp_johny, variables = "age", size = 5, color = "#371ea3") +
show_residuals(cp_neighbours, variables = "age")

---

show_rugs  

*Adds a Layer with Rugs to a Profile Plot*

**Description**

Function `show_rugs` adds a layer to a plot created with `plot.ceteris_paribus_explainer` for selected observations. Various parameters help to decide what should be plotted, profiles, aggregated profiles, points or rugs.
show_rugs

Usage

show_rugs(
  x,
  ..., 
  size = 0.5,
  alpha = 1,
  color = "#371ea3",
  variable_type = "numerical",
  sides = "b",
  variables = NULL
)

Arguments

x a ceteris paribus explainer produced with function ceteris_paribus()
...
other explainers that shall be plotted together
size a numeric. Size of lines to be plotted
alpha a numeric between 0 and 1. Opacity of lines
color a character. Either name of a color or name of a variable that should be used for
  coloring
variable_type a character. If numerical then only numerical variables will be plotted. If
categorical then only categorical variables will be plotted.
sides a string containing any of "trbl", for top, right, bottom, and left. Passed to geom
  rug.
variables if not NULL then only variables will be presented

Value

a ggplot2 layer

References

drwhy.ai/

Examples

library("DALEX")
library("ingredients")
titanic_small <- select_sample(titanic_imputed, n = 500, seed = 1313)

# build a model
model_titanic_glm <- glm(survived ~ gender + age + fare,
                          data = titanic_small,
                          family = "binomial")

explain_titanic_glm <- explain(model_titanic_glm,
                                data = titanic_small[, -8],
y = titanic_small[,8])

cp_glm <- ceteris_paribus(explain_titanic_glm, titanic_small[,1])

cp_glm

library("ranger")

rf_model <- ranger(survived ~ ., data = titanic_imputed, probability = TRUE)

explainer_rf <- explain(rf_model,
    data = titanic_imputed[-8],
    y = titanic_imputed[,8],
    label = "ranger forest",
    verbose = FALSE)

selected_passangers <- select_sample(titanic_imputed, n = 100)

cp_rf <- ceteris_paribus(explainer_rf, selected_passangers)

cp_rf

plot(cp_rf, variables = "age", color = "grey") +
    show_observations(cp_rf, variables = "age", color = "black") +
    show_rugs(cp_rf, variables = "age", color = "red")
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