

# Package ‘breakDown’

October 12, 2022

**Title** Model Agnostic Explainers for Individual Predictions

**Version** 0.2.1

**Description** Model agnostic tool for decomposition of predictions from black boxes.

Break Down Table shows contributions of every variable to a final prediction.

Break Down Plot presents variable contributions in a concise graphical way.

This package work for binary classifiers and general regression models.

**Depends** R (>= 3.0)

**Date** 2021-01-20

**License** GPL-2

**Encoding** UTF-8

**LazyData** true

**Imports** ggplot2

**RoxygenNote** 7.1.1

**Suggests** knitr, rmarkdown, e1071, kernlab, xgboost, caret,  
randomForest, DALEX, ranger, testthat

**VignetteBuilder** knitr

**URL** <https://pbiecek.github.io/breakDown/>

**BugReports** <https://github.com/pbiecek/breakDown/issues>

**NeedsCompilation** no

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betas	<i>Extract betas values of a model for specific observations</i>
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### Description

Extract betas values of a model for specific observations

### Usage

```
betas(object, newdata, ...)
```

### Arguments

object	a model
newdata	new observation(s) with columns that correspond to variables used in the model
...	unused additional parameters

### Author(s)

Joseph Larmarange

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break_down	<i>Model Agnostic Experimental Approach to Break Down Plots with Interactions</i>
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### Description

This function implements decomposition of model predictions with identification of interactions. The complexity of this function is  $O(2^*p)$  for additive models and  $O(2^*p^2)$  for interactions. This function works in similar way to step-up and step-down greedy approximations, the main difference is that in the first step the order of variables is determined. And in the second step the impact is calculated.

**Usage**

```
break_down(
  explainer,
  new_observation,
  check_interactions = TRUE,
  keep_distributions = FALSE
)
```

**Arguments**

**explainer** a model to be explained, preprocessed by function 'DALEX::explain()'.  
**new\_observation** a new observation with columns that corresponds to variables used in the model  
**check\_interactions** the origin/baseline for the 'breakDown' plots, where the rectangles start. It may be a number or a character "Intercept". In the latter case the origin will be set to model intercept.  
**keep\_distributions** if TRUE, then the distribution of partial predictions is stored in addition to the average.

**Value**

an object of the broken class

**Examples**

```
## Not run:
library("DALEX")
library("breakDown")
library("randomForest")
set.seed(1313)
# example with interaction
# classification for HR data
model <- randomForest(status ~ . , data = HR)
new_observation <- HRTest[1,]
data <- HR[1:1000,]
predict_function <- function(m,x) predict(m,x, type = "prob")[,1]

explainer_rf_fired <- explain(model,
  data = HR[1:1000,1:5],
  y = HR$status[1:1000] == "fired",
  predict_function = function(m,x) predict(m,x, type = "prob")[,1],
  label = "fired")

bd_rf <- break_down(explainer_rf_fired,
  new_observation,
  keep_distributions = TRUE)

bd_rf
```

```

plot(bd_rf)
plot(bd_rf, plot_distributions = TRUE)

bd_rf <- break_down(explainer_rf_fired,
                    new_observation,
                    check_interactions = FALSE,
                    keep_distributions = TRUE)

bd_rf
plot(bd_rf)

# example for regression - apartment prices
# here we do not have interactions
model <- randomForest(m2.price ~ . , data = apartments)
explainer_rf <- explain(model,
                        data = apartmentsTest[1:1000,2:6],
                        y = apartmentsTest$m2.price[1:1000],
                        label = "rf")

bd_rf <- break_down(explainer_rf,
                    apartmentsTest[1,],
                    check_interactions = FALSE,
                    keep_distributions = TRUE)

bd_rf
plot(bd_rf)
plot(bd_rf, plot_distributions = TRUE)

## End(Not run)

```

---

broken

*Generic Function for Breaking Down of Model Predictions*


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## Description

The broken function is a generic function for decomposition of model predictions. For linear models please use [broken.lm](#), for generic linear models please use [broken.glm](#). For all other models please use the model agnostic version [broken.default](#). Please note, that some of these functions have additional parameters.

## Usage

```
broken(model, new_observation, ...)
```

## Arguments

model	a model
new_observation	a new observation with columns that corresponds to variables used in the model
...	other parameters

**Value**

an object of the broken class

**Examples**

```
## Not run:
library("breakDown")
library("randomForest")
library("ggplot2")
set.seed(1313)
model <- randomForest(factor(left)~., data = HR_data, family = "binomial", maxnodes = 5)
predict.function <- function(model, new_observation)
  predict(model, new_observation, type="prob")[,2]
predict.function(model, HR_data[11,-7])
explain_1 <- broken(model, HR_data[11,-7], data = HR_data[, -7],
  predict.function = predict.function, direction = "down")
explain_1
plot(explain_1) + ggtitle("breakDown plot (direction=down) for randomForest model")

explain_2 <- broken(model, HR_data[11,-7], data = HR_data[, -7],
  predict.function = predict.function, direction = "down", keep_distributions = TRUE)
plot(explain_2, plot_distributions = TRUE) +
  ggtitle("breakDown distributions (direction=down) for randomForest model")

explain_3 <- broken(model, HR_data[11,-7], data = HR_data[, -7],
  predict.function = predict.function, direction = "up", keep_distributions = TRUE)
plot(explain_3, plot_distributions = TRUE) +
  ggtitle("breakDown distributions (direction=up) for randomForest model")

## End(Not run)
```

---

broken.default

*Model Agnostic Approach to Breaking Down of Model Predictions*

---

**Description**

This function implements two greedy strategies for decompositions of model predictions (see the direction parameter). Both strategies are model agnostic, they are greedy but in most cases they give very similar results. Find more information about these strategies in <https://arxiv.org/abs/1804.01955>.

**Usage**

```
## Default S3 method:
broken(
  model,
  new_observation,
  data,
  direction = "up",
```

```

    ...,
    baseline = 0,
    keep_distributions = FALSE,
    predict.function = predict
  )

```

## Arguments

model	a model, it can be any predictive model, find examples for most popular frameworks in vignettes
new_observation	a new observation with columns that corresponds to variables used in the model
data	the original data used for model fitting, should have same columns as the 'new_observation'.
direction	either 'up' or 'down' determined the exploration strategy
...	other parameters
baseline	the origin/baseline for the breakDown plots, where the rectangles start. It may be a number or a character "Intercept". In the latter case the origin will be set to model intercept.
keep_distributions	if TRUE, then the distribution of partial predictions is stored in addition to the average.
predict.function	function that will calculate predictions out of model. It shall return a single numeric value per observation. For classification it may be a probability of the default class.

## Value

an object of the broken class

## Examples

```

## Not run:
library("breakDown")
library("randomForest")
library("ggplot2")
set.seed(1313)
model <- randomForest(factor(left)~., data = HR_data, family = "binomial", maxnodes = 5)
predict.function <- function(model, new_observation)
  predict(model, new_observation, type="prob")[,2]
predict.function(model, HR_data[11,-7])
explain_1 <- broken(model, HR_data[11,-7], data = HR_data[, -7],
  predict.function = predict.function, direction = "down")
explain_1
plot(explain_1) + ggtitle("breakDown plot (direction=down) for randomForest model")

explain_2 <- broken(model, HR_data[11,-7], data = HR_data[, -7],
  predict.function = predict.function, direction = "down", keep_distributions = TRUE)
plot(explain_2, plot_distributions = TRUE) +

```

```

ggtitle("breakDown distributions (direction=down) for randomForest model")

explain_3 <- broken(model, HR_data[11,-7], data = HR_data[, -7],
  predict.function = predict.function, direction = "up", keep_distributions = TRUE)
plot(explain_3, plot_distributions = TRUE) +
  ggtitle("breakDown distributions (direction=up) for randomForest model")

## End(Not run)

```

---

broken.glm

*Breaking Down of Model Predictions for glm models*


---

## Description

Breaking Down of Model Predictions for glm models

## Usage

```

## S3 method for class 'glm'
broken(
  model,
  new_observation,
  ...,
  baseline = 0,
  predict.function = stats::predict.glm
)

```

## Arguments

model	a glm model
new_observation	a new observation with columns that corresponds to variables used in the model
...	other parameters
baseline	the origin/baseline for the breakDown plots, where the rectangles start. It may be a number or a character "Intercept". In the latter case the origin will be set to model intercept.
predict.function	function that will calculate predictions out of model (typically predict or betas)

## Value

an object of the broken class

**Examples**

```
# example for wine data
wine$qualityb <- factor(wine$quality > 5.5, labels = c("bad", "good"))
modelg <- glm(qualityb~fixed.acidity + volatile.acidity + citric.acid +
             residual.sugar + chlorides + free.sulfur.dioxide +
             total.sulfur.dioxide + density + pH + sulphates + alcohol,
             data=wine, family = "binomial")
new_observation <- wine[1,]
br <- broken(modelg, new_observation)
logit <- function(x) exp(x)/(1+exp(x))
plot(br, logit)

# example for HR_data
model <- glm(left~., data = HR_data, family = "binomial")
explain_1 <- broken(model, HR_data[1,])
explain_1
plot(explain_1)
plot(explain_1, trans = function(x) exp(x)/(1+exp(x)))

explain_2 <- broken(model, HR_data[1,], predict.function = betas)
explain_2
plot(explain_2, trans = function(x) exp(x)/(1+exp(x)))
```

---

 broken.lm

*Breaking Down of Model Predictions for lm models*


---

**Description**

Breaking Down of Model Predictions for lm models

**Usage**

```
## S3 method for class 'lm'
broken(
  model,
  new_observation,
  ...,
  baseline = 0,
  predict.function = stats::predict.lm
)
```

**Arguments**

model	a lm model
new_observation	a new observation with columns that corresponds to variables used in the model
...	other parameters



`baseline` the origin/baseline for the breakDown plots, where the rectangles start. It may be a number or a character "Intercept". In the latter case the origin will be set to model intercept.

`predict.function` function that will calculate predictions out of model (typically `predict` or `betas`)

**Value**

an object of the broken class

**Examples**

```
model <- lm(Sepal.Length~., data=iris)
new_observation <- iris[1,]
br <- broken(model, new_observation)
plot(br)

# works for interactions as well
model <- lm(Sepal.Length ~ Petal.Width*Species, data = iris)
summary(model)

new_observation <- iris[1,]
br <- broken(model, new_observation)
br
plot(br)

br2 <- broken(model, new_observation, predict.function = betas)
br2
plot(br2)
```

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HR_data	<i>Why are our best and most experienced employees leaving prematurely?</i>
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**Description**

A dataset from Kaggle competition Human Resources Analytics. <https://www.kaggle.com/>

**Format**

A data frame with 14999 rows and 10 variables

**Details**

- `satisfaction_level` Level of satisfaction (0-1)
- `last_evaluation` Time since last performance evaluation (in Years)
- `number_project` Number of projects completed while at work
- `average_monthly_hours` Average monthly hours at workplace

- time\_spend\_company Number of years spent in the company
- Work\_accident Whether the employee had a workplace accident
- left Whether the employee left the workplace or not (1 or 0) Factor
- promotion\_last\_5years Whether the employee was promoted in the last five years
- sales Department in which they work for
- salary Relative level of salary (high)

### Source

Dataset HR-analytics from <https://www.kaggle.com>

---

plot.broken

*Break Down Plot*

---

### Description

Break Down Plot

### Usage

```
## S3 method for class 'broken'
plot(
  x,
  trans = I,
  ...,
  top_features = 0,
  min_delta = 0,
  add_contributions = TRUE,
  vcolors = c(`-1` = "#f05a71", `0` = "#371ea3", `1` = "#8bdcbe", X = "#371ea3"),
  digits = 3,
  rounding_function = round,
  plot_distributions = FALSE
)
```

### Arguments

x	the model model of 'broken' class
trans	transformation that shall be applied to scores
...	other parameters
top_features	maximal number of variables from model we want to plot
min_delta	minimal stroke value of variables from model we want to plot
add_contributions	shall variable contributions to be added on plot?
vcolors	named vector with colors

**digits**                number of decimal places (round) or significant digits (signif) to be used. See the rounding\_function argument

**rounding\_function**  
function that is to used for rounding numbers. It may be signif() which keeps a specified number of significant digits. Or the default round() to have the same precision for all components

**plot\_distributions**  
if TRUE then distributions of conditional propotions will be plotted. This requires keep\_distributions=TRUE in the broken.default().

## Value

a ggplot2 object

## Examples

```
## Not run:
library("breakDown")
library("randomForest")
library("ggplot2")
set.seed(1313)
model <- randomForest(factor(left)~., data = HR_data, family = "binomial", maxnodes = 5)
predict.function <- function(model, new_observation)
  predict(model, new_observation, type="prob")[,2]
predict.function(model, HR_data[11,-7])
explain_1 <- broken(model, HR_data[11,-7], data = HR_data[, -7],
  predict.function = predict.function, direction = "down")
explain_1
plot(explain_1) + ggtitle("breakDown plot (direction=down) for randomForest model")

explain_2 <- broken(model, HR_data[11,-7], data = HR_data[, -7],
  predict.function = predict.function, direction = "down", keep_distributions = TRUE)
plot(explain_2, plot_distributions = TRUE) +
  ggtitle("breakDown distributions (direction=down) for randomForest model")

explain_3 <- broken(model, HR_data[11,-7], data = HR_data[, -7],
  predict.function = predict.function, direction = "up", keep_distributions = TRUE)
plot(explain_3, plot_distributions = TRUE) +
  ggtitle("breakDown distributions (direction=up) for randomForest model")

model <- lm(quality~., data=wine)
new_observation <- wine[1,]
br <- broken(model, new_observation)
plot(br)
plot(br, top_features = 2)
plot(br, top_features = 2, min_delta = 0.01)

## End(Not run)
```

---

print.broken	<i>Break Down Print</i>
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---

### Description

Break Down Print

### Usage

```
## S3 method for class 'broken'
print(x, ..., digits = 3, rounding_function = round)
```

### Arguments

x	the model model of 'broken' class
...	other parameters
digits	number of decimal places (round) or significant digits (signif) to be used. See the rounding_function argument
rounding_function	function that is to used for rounding numbers. It may be signif() which keeps a specified number of significant digits. Or the default round() to have the same precision for all components

### Value

a data frame

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wine	<i>White Wine Quality Data</i>
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### Description

White wine quality data related to variants of the Portuguese "Vinho Verde" wine. For more details, consult: <http://www.vinhoverde.pt/en/> or the reference Cortez et al., 2009.

### Format

A data frame with 4898 rows and 12 variables

**Details**

A dataset downloaded from UCI Machine Learning Database archive.ics.uci.edu/ml/machine-learning-databases/wine-quality/winequality-white.cs

- fixed.acidity
- volatile.acidity
- citric.acid
- residual.sugar
- chlorides
- free.sulfur.dioxide
- total.sulfur.dioxide
- density
- pH
- sulphates
- alcohol
- quality

**Source**

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.

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