

# imlplots

*Julia Fried, Tobias Riebe, Christian Scholbeck*

*2018-04-11*

## imlplots: interpretable machine learning plots

**imlplots** is an R package that provides an interactive Shiny dashboard for three kinds of Interpretable Machine Learning (IML) plots

- Partial Dependence Plots (PDP)
- Individual Conditional Expectation (ICE) plots
- Accumulated Local Effect (ALE) plots

## Installation

The package can be installed directly from github with devtools

```
# install.packages("devtools")
devtools::install_github('juliafried/imlplots')
library(imlplots)
```

## Quickstart

You can fit classification and regression problems from the **mlr** package and analyse possible interaction effects in a Shiny dashboard.

For quickstart we take the popular Boston Housing data, where we want to predict the median housing price in Boston.

```
print(summarizeColumns(boston)[, -c(5, 6, 7)], digits = 4)
```

##	name	type	na	mean	min	max	nlevs
## 1	crim	numeric	0	3.6135	0.00632	88.976	0
## 2	zn	numeric	0	11.3636	0.00000	100.000	0
## 3	indus	numeric	0	11.1368	0.46000	27.740	0
## 4	chas	factor	0	NA	35.00000	471.000	2
## 5	nox	numeric	0	0.5547	0.38500	0.871	0
## 6	rm	numeric	0	6.2846	3.56100	8.780	0
## 7	age	numeric	0	68.5749	2.90000	100.000	0
## 8	dis	numeric	0	3.7950	1.12960	12.127	0
## 9	rad	factor	0	NA	17.00000	132.000	9
## 10	tax	numeric	0	408.2372	187.00000	711.000	0
## 11	ptratio	numeric	0	18.4555	12.60000	22.000	0
## 12	black	numeric	0	356.6740	0.32000	396.900	0
## 13	lstat	numeric	0	12.6531	1.73000	37.970	0
## 14	medv	numeric	0	22.5328	5.00000	50.000	0

For using **imlplots** Shiny dashboard, three input arguments need to be specified

- **data** - the input data

- `task`- the learning task
- `models` - one or several trained models

We create a regression task with `medv` as target variable. The task structure is determined by `mlr` package.

```
boston.task = makeRegrTask(data = boston, target = "medv")
```

The `imlplots` dashboard allows the comparison of multiple learning algorithms, therefore we fit two different models - first a random forest and second a GLM.

```
rf.mod = train("regr.randomForest", boston.task)
glm.mod = train("regr.glm", boston.task)
```

The input for the Shiny app is a list of learners.

```
mod.list = list(rf.mod, glm.mod)
```

Now the Shiny app can be used.

```
imlplots(data = boston, task = boston.task, models = mod.list)
```

## Code for Copy & Paste

```
boston.task = makeRegrTask(data = boston, target = "medv")

rf.mod = train("regr.randomForest", boston.task)
glm.mod = train("regr.glm", boston.task)
mod.list = list(rf.mod, glm.mod)

imlplots(data = boston, task = boston.task, models = mod.list)
```

## Further Examples

### IML Plots for Regression Tasks

To show how you can use the `imlplots` Shiny app for regression tasks we use fire data, where the burned area of forests due to fires should be analyzed.

```
print(summarizeColumns(fire)[, -c(5, 6, 7)], digits = 4)
```

##	name	type	na	mean	min	max	nlevs
## 1	month	factor	0	NA	1.0	184.0	12
## 2	day	factor	0	NA	54.0	95.0	7
## 3	FFMC	numeric	0	90.64468	18.7	96.2	0
## 4	DMC	numeric	0	110.87234	1.1	291.3	0
## 5	DC	numeric	0	547.94004	7.9	860.6	0
## 6	ISI	numeric	0	9.02166	0.0	56.1	0
## 7	temp	numeric	0	18.88917	2.2	33.3	0
## 8	RH	integer	0	44.28820	15.0	100.0	0
## 9	wind	numeric	0	4.01760	0.4	9.4	0
## 10	rain	numeric	0	0.02166	0.0	6.4	0
## 11	area	numeric	0	12.84729	0.0	1090.8	0

The target variable is `area`, which is between 0.00 and 1090.84 ha.

```
summary(fire$area)
```

```
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##      0.00   0.00   0.52   12.85   6.57 1090.84
```

We create a regression task with target variable `area`.

```
fire.task = makeRegrTask(data = fire, target = "area")
```

Next we train several `mlr` models and save them in a list of models. Note: The order in your model list will determine the model order in the Shiny dashboard.

```
fire.rf = train("regr.randomForest", fire.task)
fire.glm = train("regr.glm", fire.task)
fire.lm = train("regr.lm", fire.task)

mod.list = list(fire.rf, fire.glm, fire.lm)
```

Now we can open the `imlplots` Shiny app.

```
imlplots(data = fire, task = fire.task, models = mod.list)
```

The Shiny dashboard contains four tabs

- Data
- Settings
- Plots
- Learner Summary

## Data

The **Data** tab shows your input data. This data is taken to generate IML plots. If you want to check how changes in the data effect your plot, you can simply filter in the **Data** tab.

LMU Data Science Innovationslabor Reload application

Interactive plots for interpretable machine learning

Data Settings Plots Learner Summary

Data used for plotting ICE curves

Select observations to sample from

Plot all sampled observations

Show 10 entries Search:

	month	day	FFMC	DMC	DC	ISI	temp	RH	wind	rain	area
1	mar	fri	86.2	26.2	94.3	5.1	8.2	51	6.7	0	0
2	oct	tue	90.6	35.4	669.1	6.7	18	33	0.9	0	0
3	oct	sat	90.6	43.7	686.9	6.7	14.6	33	1.3	0	0
4	mar	fri	91.7	33.3	77.5	9	8.3	97	4	0.2	0
5	mar	sun	89.3	51.3	102.2	9.6	11.4	99	1.8	0	0
6	aug	sun	92.3	85.3	488	14.7	22.2	29	5.4	0	0
7	aug	mon	92.3	88.9	495.6	8.5	24.1	27	3.1	0	0
8	aug	mon	91.5	145.4	608.2	10.7	8	86	2.2	0	0
9	sep	tue	91	129.5	692.6	7	13.1	63	5.4	0	0
10	sep	sat	92.5	88	698.6	7.1	22.8	40	4	0	0

Showing 1 to 10 of 517 entries

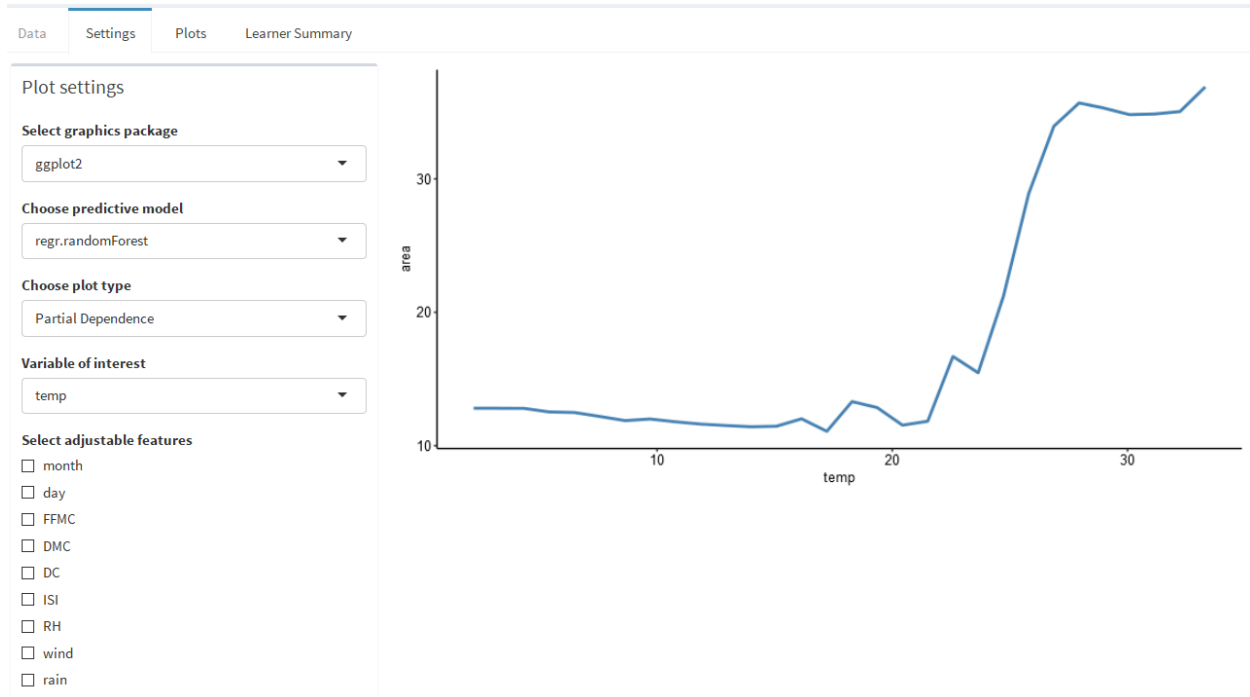
Previous 1 2 3 4 5 ... 52 Next

For filtering two options are given

1. **Plot all sampled observations:** In this setting you can filter via the filters beneath the column titles and all rows will be used for plotting.
2. **Plot individual observations:** In this setting after using the filters, you have to manually select specific rows.

## Settings

The next tab **Settings** contains all possible plot settings and the selected IML plot.



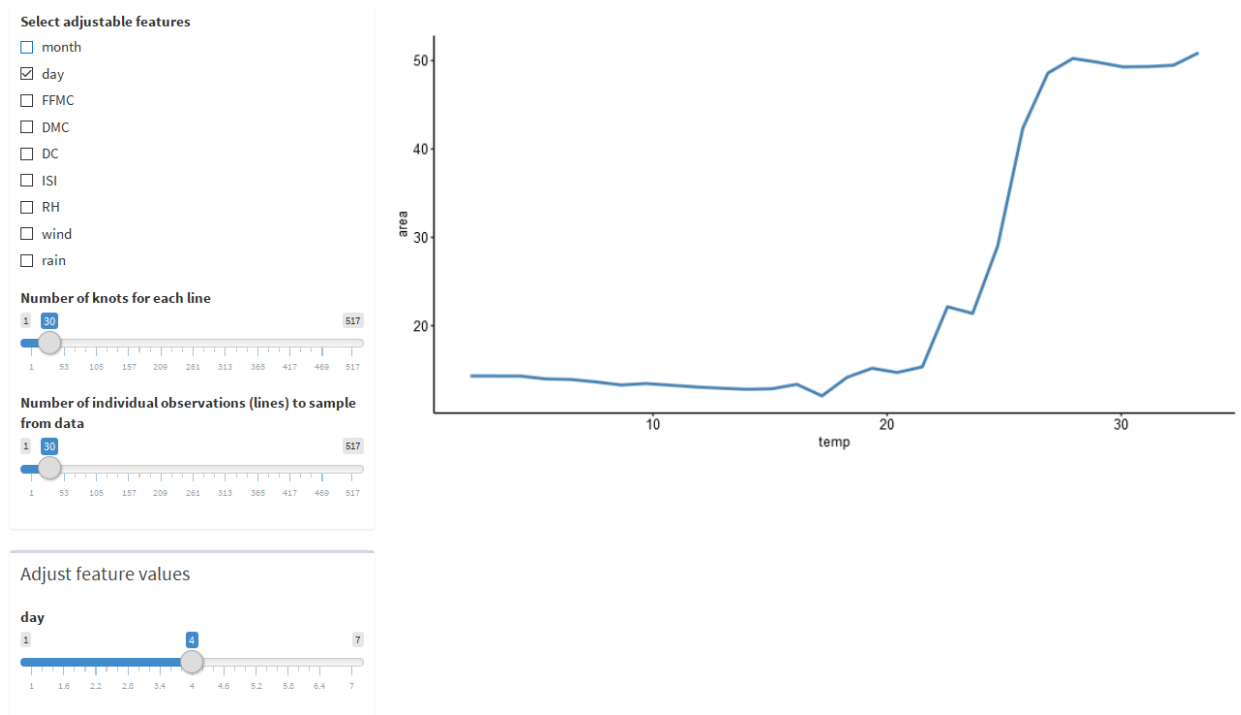
There are various settings

1. **Select graphics package:** You can select the graphics package - we offer **ggplot2** and **plotly**. Use **ggplot2** if your computer is not the fastest one.
2. **Choose predictive model:** Choose one of your fitted models. The order in the dropdown is the order of your list.
3. **Choose plot type:** We offer PDP, ICE and ALE plots. If you select ICE plot, you will get a new selection field. Possible are **centered** and **regular** ICE plots.
4. **Variable of interest:** This dropdown will determine the x-axis of your plot and will determine the effect that is plotted.

## PDP

On the right side of the dashboard page, the selected plot is shown.

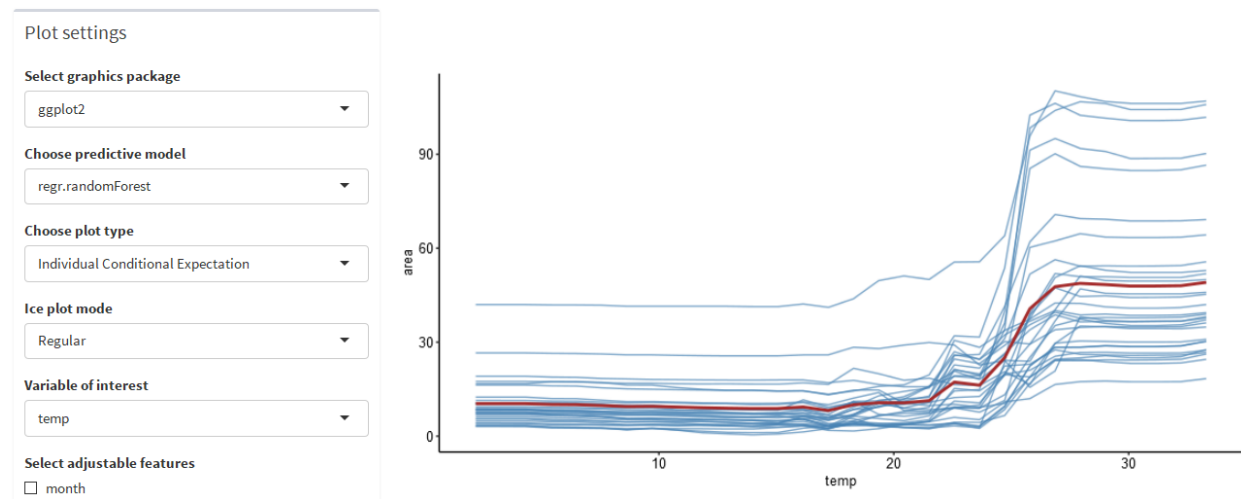
To check out effects, you can turn on **Select adjustable features**. This option allows you to set one of the variables to a specific value.



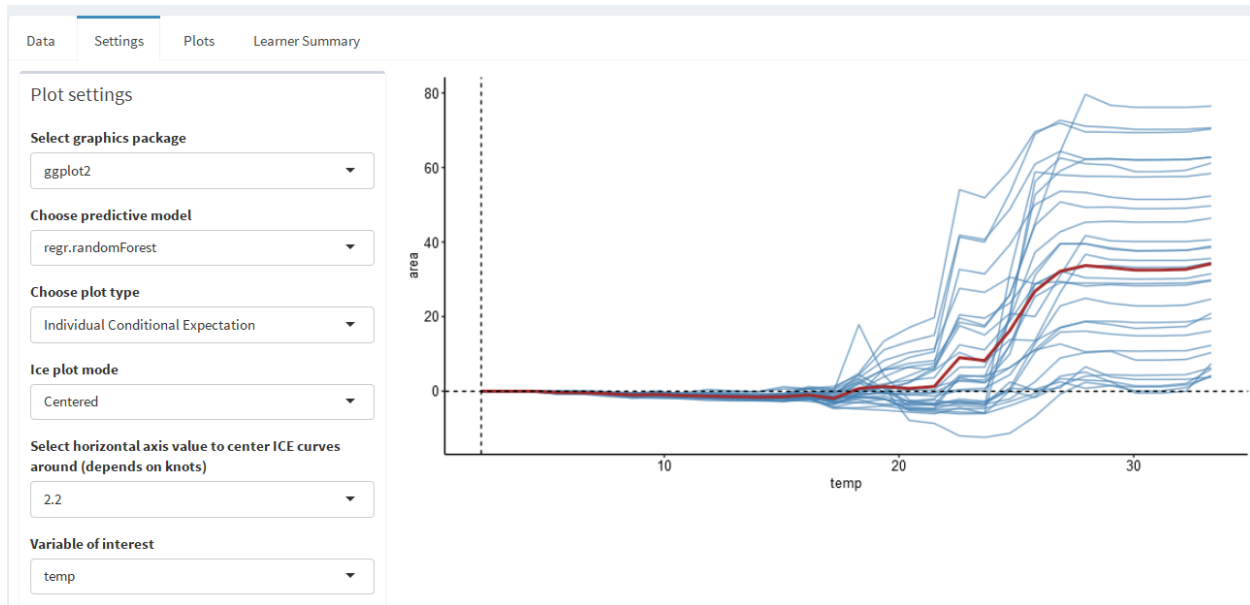
It is also possible to change the number of knots and lines (individual observations) with the shown sliders.

## ICE Plot

The ICE plot contains all sampled, individual observations in blue. The red line is from PDP.

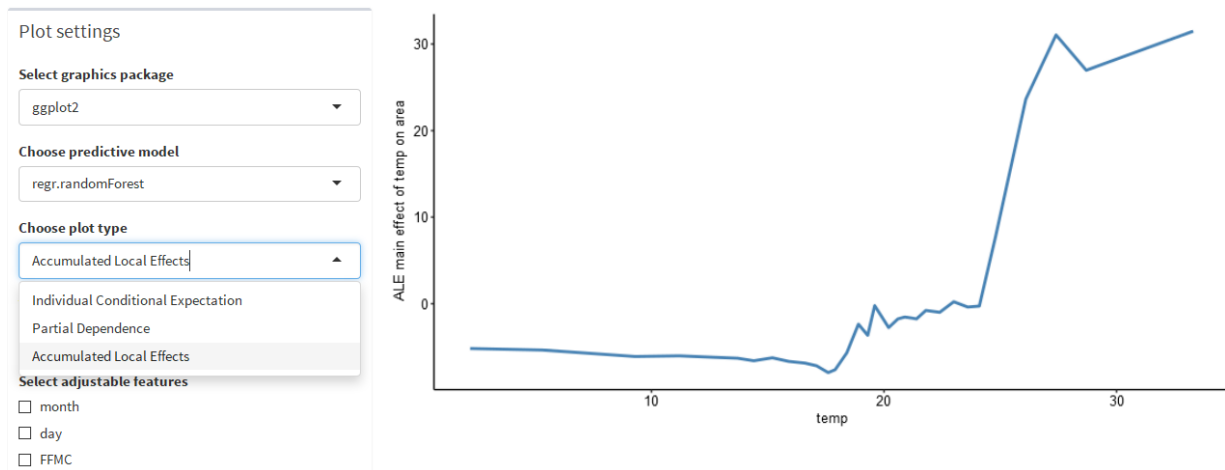


As described above, you can select between **Regular** and **Centered** ICE plots.



## ALE Plot

The ALE plot can be selected, too. Please keep in mind, that the ALE plot has a different y-axis than the PDP and ICE plot.



For ALE plots you can switch between two **ALE Plot Modes**. The **Main Effects** mode allows you to select one variable of interest and shows its interaction effect. The **Second Order Effects** setting allows to select another **ALE interaction variable** and therefore shows the effect for this extra variable too. If you select **plotly** as graphics package, the second order effects ALE plot will be a 3D plot.

Select graphics package

plotly (resource intensive)

Choose predictive model

regr.randomForest

Choose plot type

Accumulated Local Effects

ALE Plot Mode

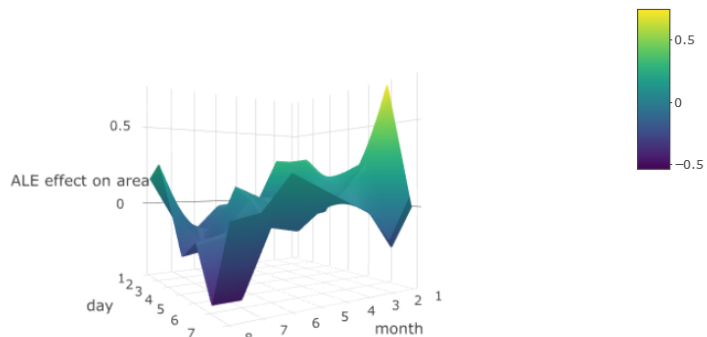
Second Order Effects

Variable of interest

month

ALE interaction variable

day



## Plots

The third tab **Plots** shows the selected IML plot in full screen via the sub-tab **Zoomed plot**. The sub-tab **Scatterplot** shows the filtered and unfiltered scatterplot between the **variable of interest** and the **target variable** of the model.

In the **Data** tab we filtered for a high value of burned area and selected three individual observations.

Data Settings Plots Learner Summary

Data used for plotting ICE curves

Select observations to sample from

Plot individual observations

Show 10 entries

Search:

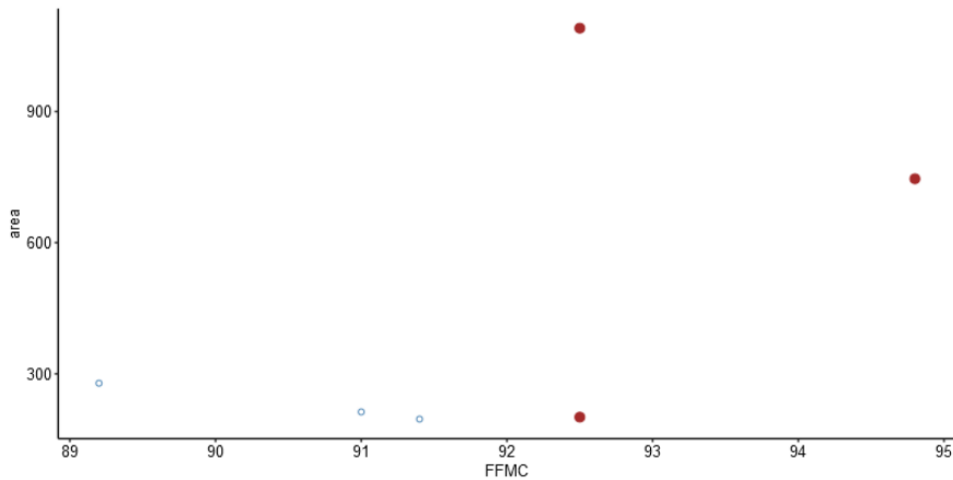
	month	day	FFMC	DMC	DC	ISI	temp	BH	wind	rain	area
	All	All	All	All	All	All	All	All	All	All	193.31 ... 1090.8
236	8	7	91.4	142.4	601.4	10.6	19.6	41	5.8	0	196.48
237	9	6	92.5	121.1	674.4	8.6	18.2	46	1.8	0	200.94
238	9	2	91	129.5	692.6	7	18.8	40	2.2	0	212.88
239	9	6	92.5	121.1	674.4	8.6	25.1	27	4	0	1090.84
416	8	4	94.8	222.4	698.6	13.9	27.5	27	4.9	0	746.28
480	7	1	89.2	103.9	431.6	6.4	22.6	57	4.9	0	278.53

Showing 1 to 6 of 6 entries (filtered from 517 total entries)

Previous 1 Next

The filtered data scatterplot shows the selected high area values and also the three individual observations (in red).

## Filtered data



The unfiltered data scatterplot shows all data points and also the three individual observations (in red).

## Learner Summary

The fourth tab **Learner Summary** shows the currently selected learner summary. If you want to see another summary, you have to select another model in the **Settings** tab.

Data
Settings
Plots
Learner Summary

```

[1] ""
[2] "Call:"
[3] " randomForest(x = data[["data"]], y = data[["target"]], keep.inbag = if (is.null(keep.inbag)) TRUE else keep.inbag) "
[4] "           Type of random forest: regression"
[5] "           Number of trees: 500"
[6] "No. of variables tried at each split: 3"
[7] ""
[8] "           Mean of squared residuals: 4187.245"
[9] "           % Var explained: -3.54"

```

## Code for Copy & Paste

```

library(imlplots)

fire.rf = train("regr.randomForest", fire.task)
fire.glm = train("regr.glm", fire.task)
fire.lm = train("regr.lm", fire.task)

mod.list = list(fire.rf, fire.glm, fire.lm)

implots(data = fire, task = fire.task, models = mod.list)

```



## IML Plots for Classification Tasks

For the classification example only the differences to the regression example will be explained. We use the titanic data set, where the aim is to predict the survival chance.

```
print(summarizeColumns(titanic)[, -c(5, 6, 7)], digits = 4)
```

##	name	type	na	mean	min	max	nlevs
## 1	Pclass	factor	0	NA	277.0000	709.0	3
## 2	Survived	factor	0	NA	500.0000	809.0	2
## 3	Sex	factor	0	NA	466.0000	843.0	2
## 4	Age	numeric	0	29.5032	0.1667	80.0	0
## 5	Sibsp	integer	0	0.4989	0.0000	8.0	0
## 6	Parch	integer	0	0.3850	0.0000	9.0	0
## 7	Fare	numeric	0	33.2811	0.0000	512.3	0
## 8	Embarked	factor	0	NA	2.0000	914.0	4
## 9	farePp	numeric	0	20.5090	0.0000	512.3	0
## 10	deck	factor	0	NA	1.0000	1014.0	9
## 11	portside	factor	0	NA	110.0000	1059.0	3

Again we create a task and fit a model.

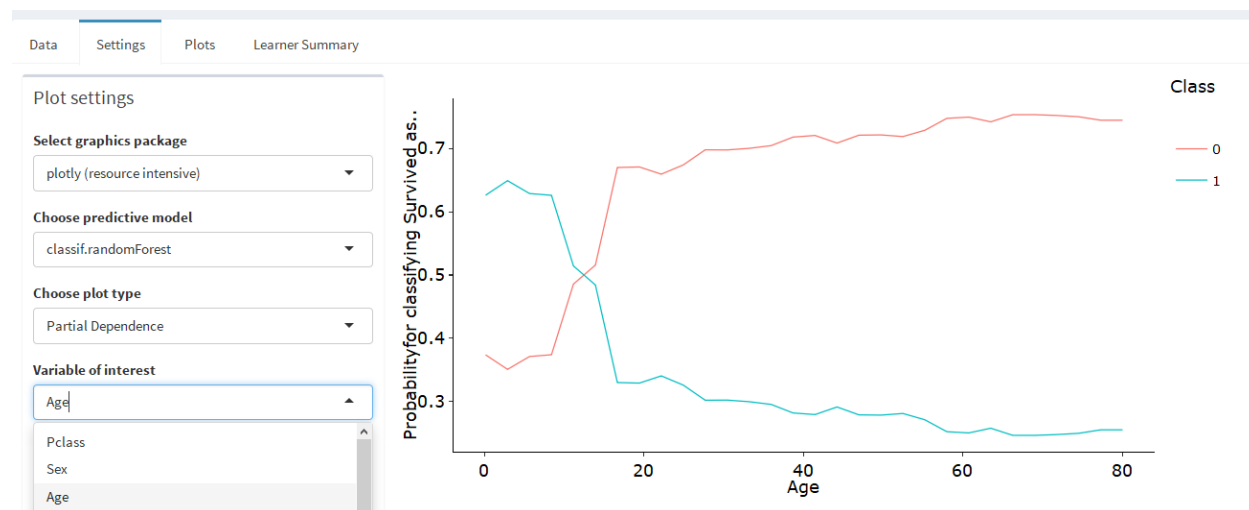
```
library(imlplots)
```

```
titanic.task = makeClassifTask(data = titanic, target = "Survived")  
titanic.rf = train("classif.randomForest", titanic.task)
```

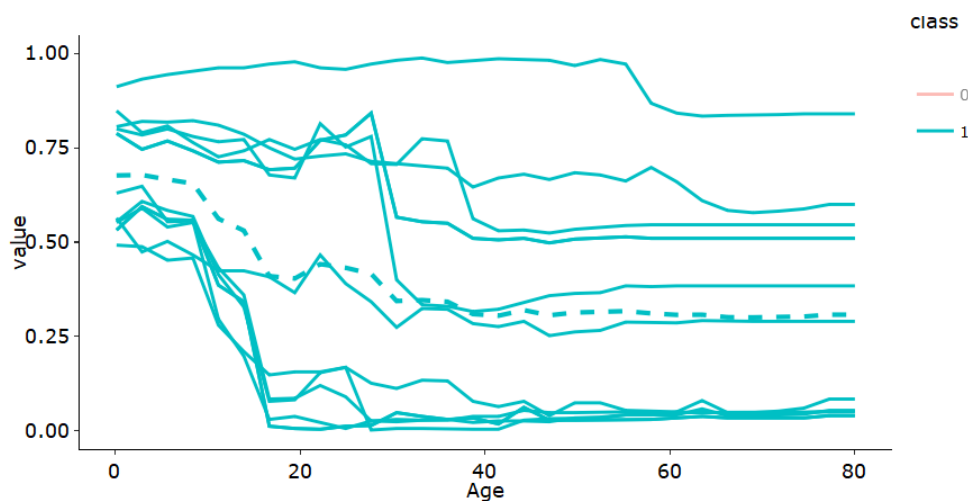
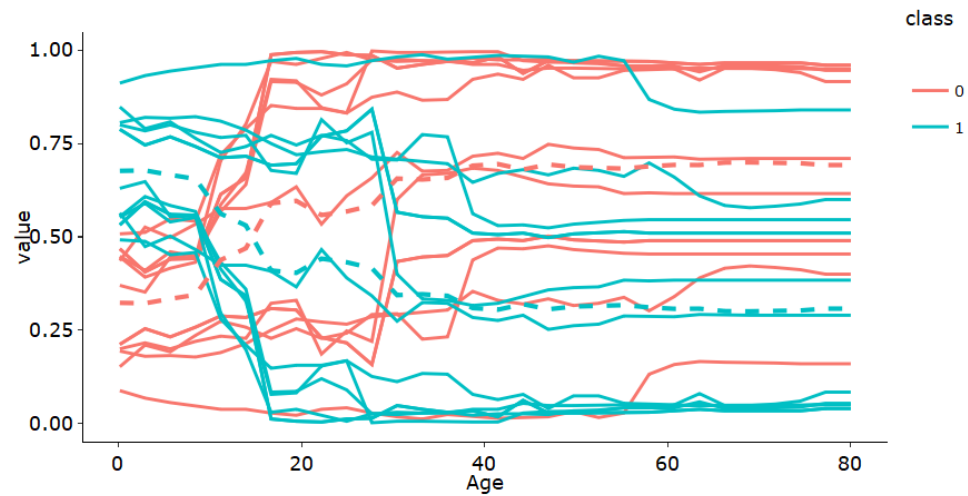
Next we open the Shiny dashboard.

```
implots(data = titanic, task = titanic.task, titanic.rf)
```

This time it is useful to select plotly in the Select graphics package dropdown.



This allows you to deselect single classes to increase the visibility of individual lines, which is very useful for ICE plot.



Please note that there is no second-order ALE plot for classification tasks.

### Code for Copy & Paste

```
library(imlplots)

titanic.task = makeClassifTask(data = titanic, target = "Survived")
titanic.rf = train("classif.randomForest", titanic.task)

implots(data = titanic, task = titanic.task, titanic.rf)
```

## References

- References