Introduction to Machine Learning in R
NPFL 054

Easy homework assigned on April 29, 2022

Contact teacher: Martin Holub
holub@ufal.mff.cuni.cz

In all tasks specified below you will work with dataset `'Auto'`, which is a part of *ISLR* package available in R. You will do a regression task and build a model to predict the value of `mpg` attribute using 7 features:

mpg ~ cylinders + displacement + horsepower + weight + acceleration + year + origin.

```
> library(ISLR)
> str(Auto)
'data.frame':      392 obs. of  9 variables:
 $ mpg         : num  18 15 18 16 17 15 14 14 14 15 ...
 $ cylinders   : num  8 8 8 8 8 8 8 8 8 8 ...
 $ displacement: num  307 350 318 304 302 429 454 440 455 390 ...
 $ horsepower  : num  130 165 150 150 140 198 220 215 225 190 ...
 $ weight      : num  3504 3693 3436 3433 3449 ...
 $ acceleration: num  12 11.5 11 12 10.5 10 9 8.5 10 8.5 ...
 $ year        : num  70 70 70 70 70 70 70 70 70 70 ...
 $ origin      : Factor w/ 3 levels "USA","Europe",..: 1 1 1 1 1 1 1 1 1 1 ...
 $ name        : Factor w/ 304 levels "amc ambassador brougham",..: 49 36 231 2 ...
```

Here is an example how to build a *Boosting Trees* (BT) regression model using `gbm` package:

```
> library(gbm)
> model.boosting = gbm(mpg ~ cylinders + displacement + horsepower + weight +
                             acceleration + year + origin,
                       data = Auto, distribution = "gaussian",
                       n.trees = 500, shrinkage = 0.01, interaction.depth = 2)
```

You can use the example code related to boosting trees and posted on the course web page.

Task 1 – Boosting Trees and the number of splits *d*

Build a BT model and experiment with parameter d (`interaction.depth`). Take into consideratin also $d = 1$ (stumps). For different values of d make plots to show how the model performace depends on the number of trees. To estimate generalization error use 8-fold or 4-fold cross-validation.

Task 2 – Boosting Trees and overfitting

Can a BT model overfit? Experiment with parameters λ (`shrinkage`) and B (`n.trees`) and find some settings in which the model obviously underfits or overfits. Also, try to find an 'optimal' settings. To estimate generalization error use 8-fold or 4-fold cross-validation. Make a plot to illustrate how the model performace depends on the model complexity.

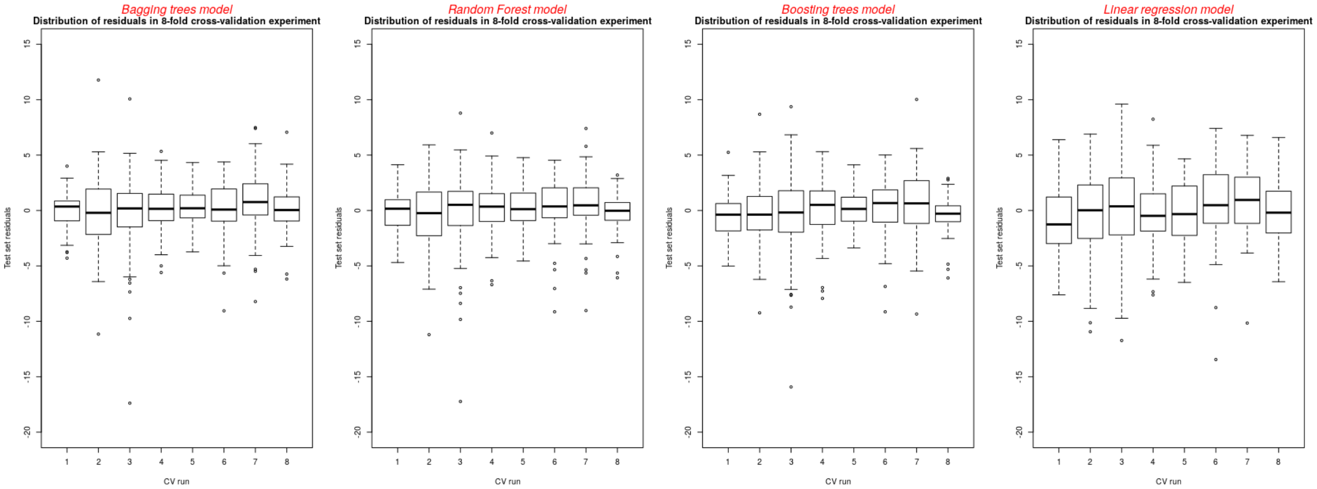
Task 3 – Boosting trees and Random Forest

Compare Boosting Trees and Random Forest models with 1000 trees. Try to tune other paramaters to get best performance. To estimate generalization error use 8-fold or 4-fold cross-validation. Which of the two methods is better for the given data?

Task 4 – Boosting trees and Linear Regression

Compare Boosting Trees and Linear Regression models. To estimate generalization error use 8-fold or 4-fold cross-validation. When you compare the two methods, also look at the distribution of residuals in the union of cross-validation test sets.

Illustration – output of the example code posted on the course web page.


Bagging trees model
Distribution of residuals in 8-fold cross-validation experiment
Random Forest model
Distribution of residuals in 8-fold cross-validation experiment
Boosting trees model
Distribution of residuals in 8-fold cross-validation experiment
Linear regression model
Distribution of residuals in 8-fold cross-validation experiment
Test set residuals
CV run