Weight Lifting Exercises

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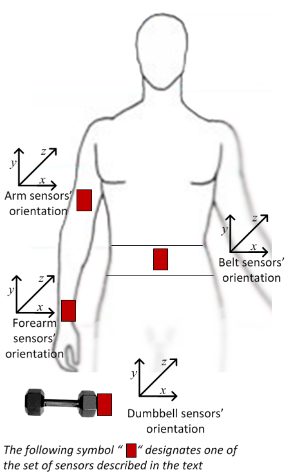
Summary

Six young health participants were asked to perform one set of 10 repetitions of the Unilateral Dumbbell Biceps Curl in five different fashions: exactly according to the specification (Class A), throwing the elbows to the front (Class B), lifting the dumbbell only halfway (Class C), lowering the dumbbell only halfway (Class D) and throwing the hips to the front (Class E). (Velloso et al. 2013)

As shown in the picture below, three sets of sensors were placed in different parts of the body using a Belt, a Glove and an Armband. Another set of sensors was placed in the Dumbbell. Each set of sensors has an Accelerometer, a Gyroscope and a Mgnetomete, and the collected metrics are the tridimentional raw data (X, Y and Z) from each sensor. Each measurement also has the calculated Euler angles: Roll, Pitch and Yaw. All these metrics were recorded together with the activities (Classe), participant data, timestamps and other statistics.



More details of the experiment available at: http://groupware.les.inf.puc-rio.br/har#weight_lifting_exercises#ixzz3SObtcRBO (http://groupware.les.inf.puc-rio.br/har#weight_lifting_exercises#ixzz3SObtcRBO)

Participants of the class were asked to train a classifier able to identify the performed activity based on the recorded metrics, provided a training file and a test file. As part of the assignment, the test file is for evaluation only, so it can't be used during the training process. So I splitted the training file in two different sets, where the new train set is 75% of the original training file and the test set is 25% of the original training file, as below:

```
set.seed(1234)
train = createDataPartition(activities$classe, p=0.75, list=F)
trainingActivities = activities[train,]
testingActivities = activities[-train,]
```

Feature Selection and Preprocessing

Empty values

Feature selection was performed in the new train set. As mentioned before, there are 8 statistics calculated per exercise repetition. Each of these statistical measures is blank most of the time, so I chose to drop every measure that matches one of the following names: Kurtosis, Skewness, Max, Min, Amplitude, Var, Avg, Stddev

A total of 100 measures were removed in this step.

Unrelated Columns

From the remaining fields I also removed those that identify the participants, the repetitions, and the time windows:

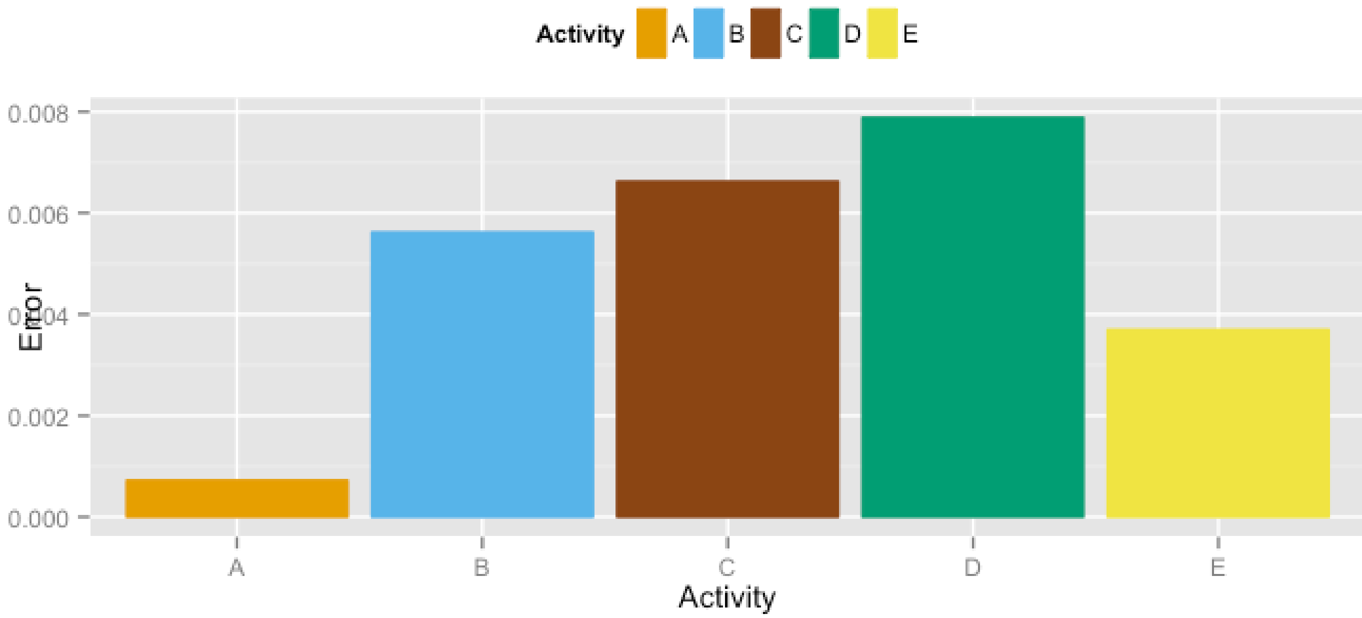
Unrelated	Unrelated
X	user_name
raw_timestamp_part_1	raw_timestamp_part_2
cvtd_timestamp	new_window
num_window	

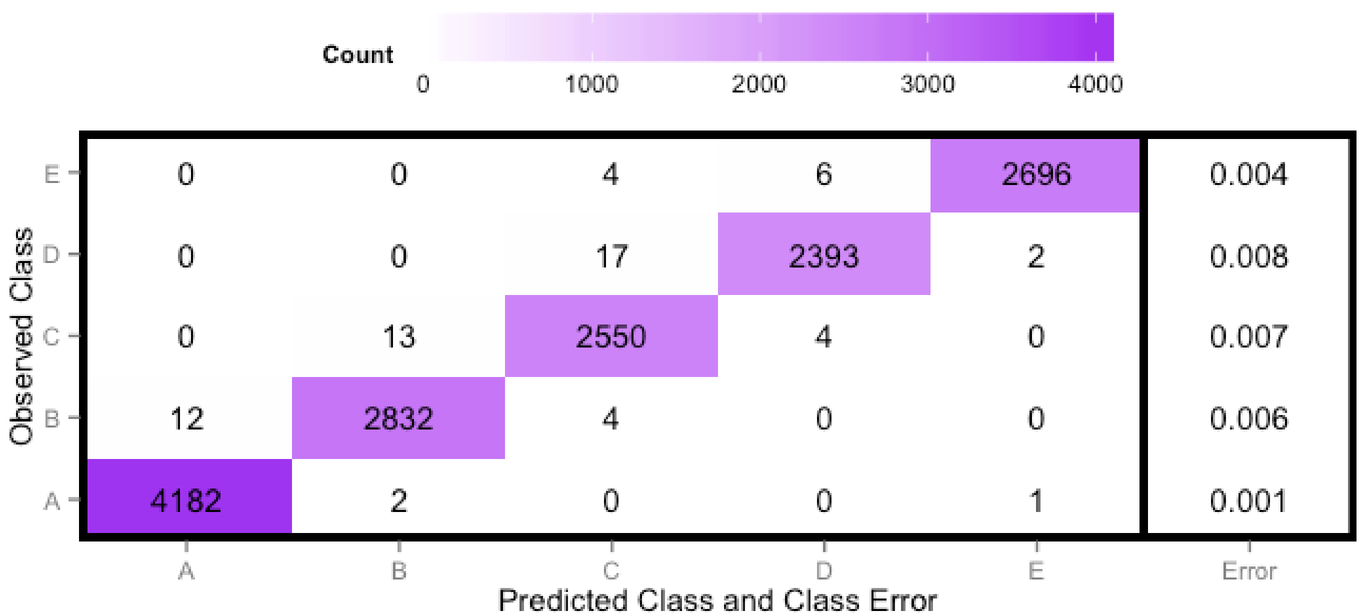
Training

My learning method of choice was Random Forests. The model was trained using as predictors all raw and calculates measures collected during the activities, as below.

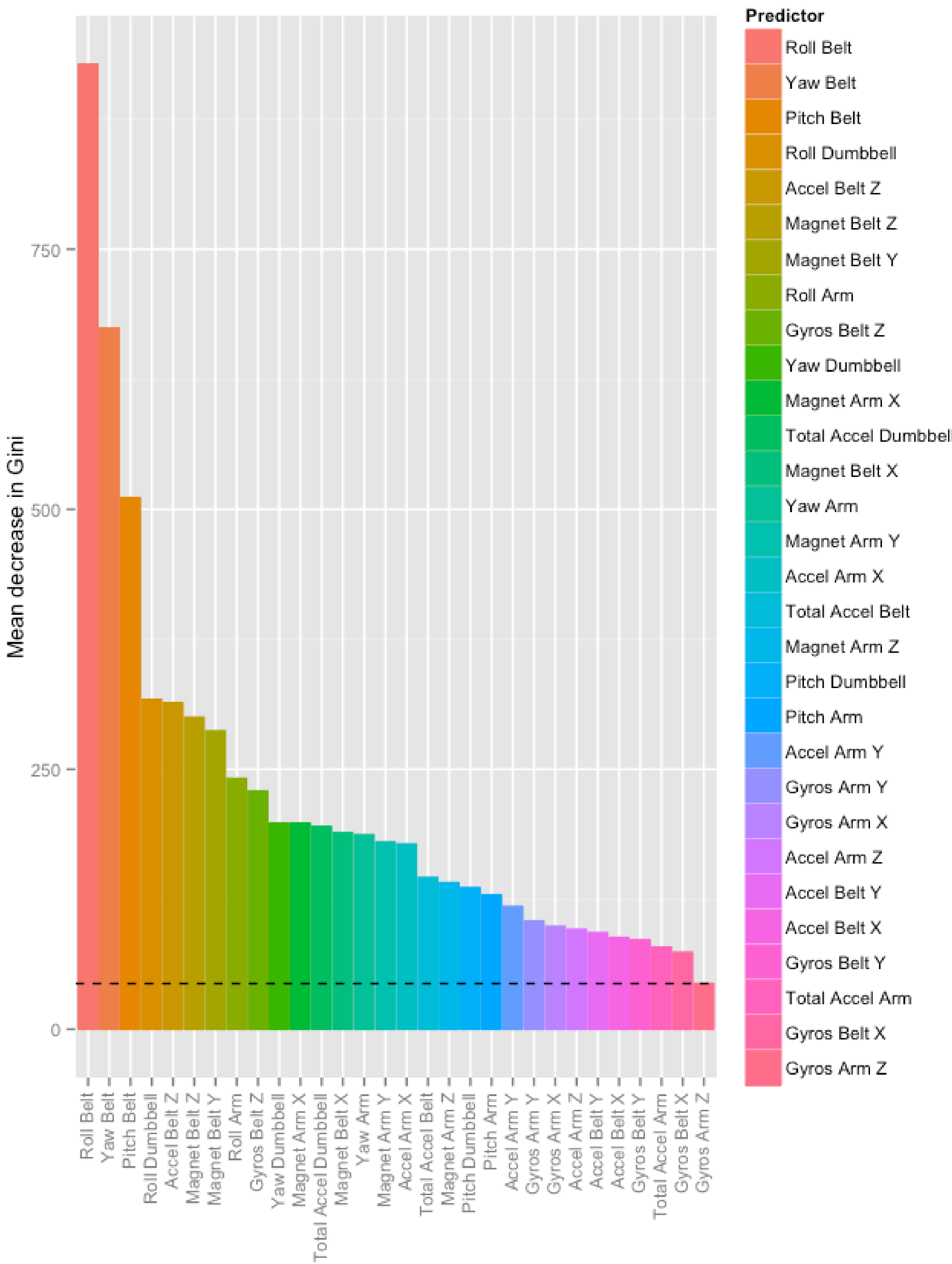
```
mForest = randomForest(y=trainingActivities$classe, x=trainingActivities[, -53], ntree=50
0, replace=T)
```

Here is the Training Classification Error per class, together with the Training Confusion Matrix. (Functions to create this graphs adapted from https://github.com/ua-snap/shiny-apps/tree/master/random_forest_example/ (https://github.com/ua-snap/shiny-apps/tree/master/random_forest_example/))





Another important metric from Random Forests is the Variable Importance, here presented using Gini, measuring the redution in Classification Error caused by the inclusion of each predictor, limited to the 30 most important predictors.



Out of Sample Accuracy

```
cMatrix = confusionMatrix(testingActivities$classe, predict(mForest, testingActivities[,
-53]))

# Out of Sample Accuracy
Accuracy = round(cMatrix$overall[1], 4)

# 95% Confidence Interval
ConfInt = round(cMatrix$overall[c(3, 4)], 4)
```

The accuracy measured using the reserved testing set is 0.9953, with a 95% Confidence Interval of (0.993, 0.997).

Below I present the Balanced Accuracy per Class, plus the measures of Sensitivity and Specificity.

	Sensitivity	Specificity	Balanced Accuracy
Class: A	0.9993	1.0000	0.9996
Class: B	0.9885	0.9992	0.9939
Class: C	0.9883	0.9970	0.9927
Class: D	0.9987	0.9981	0.9984
Class: E	1.0000	1.0000	1.0000

Assignment Test Submission

Finally, here is the code to predict the answers for the Assignment Test Submission.

```
testActivities = read.csv("data/pml-testing.csv", header=T, comment.char="", quote="\"",
col.names = activitiesNames)
# Drop all unwanted/unimportant columns
testActivities = testActivities[, -unwantedColumns]
testActivities = testActivities[, -which(names(testActivities) %in% otherUnwantedCols)]

answers = predict(mForest, testActivities[, -53])
```

References

Velloso, Eduardo, Andreas Bulling, Hans Gellersen, Wallace Ugulino, and Hugo Fuks. 2013. "Qualitative Activity Recognition of Weight Lifting Exercises." In *Proceedings of the 4th Augmented Human International Conference*, 116–23. AH '13. New York, NY, USA: ACM. doi:10.1145/2459236.2459256 (http://dx.doi.org/10.1145/2459236.2459256). http://doi.acm.org/10.1145/2459236.2459256 (http://doi.acm.org/10.1145/2459236.2459256).