Practical Machine Learning

Regina Hong

27 May 2017

Background

Using devices such as Jawbone Up, Nike FuelBand, and Fitbit it is now possible to collect a large amount of data about personal activity relatively inexpensively. These type of devices are part of the quantified self movement - a group of enthusiasts who take measurements about themselves regularly to improve their health, to find patterns in their behavior, or because they are tech geeks. One thing that people regularly do is quantify how much of a particular activity they do, but they rarely quantify how well they do it. In this project, your goal will be to use data from accelerometers on the belt, forearm, arm, and dumbell of 6 participants. They were asked to perform barbell lifts correctly and incorrectly in 5 different ways. More information is available from the website here: http://groupware.les.inf.puc-rio.br/har (see the section on the Weight Lifting Exercise Dataset).

Data

The data for this project come from this source: http://groupware.les.inf.puc-rio.br/har. If you use the document you create for this class for any purpose please cite them as they have been very generous in allowing their data to be used for this kind of assignment.

The training data for this project are available here:

https://d396qusza40orc.cloudfront.net/predmachlearn/pml-training.csv

The test data are available here:

https://d396qusza40orc.cloudfront.net/predmachlearn/pml-testing.csv

What you should submit

The goal of your project is to predict the manner in which they did the exercise. This is the "classe" variable in the training set. You may use any of the other variables to predict with. You should create a report describing how you built your model, how you used cross validation, what you think the expected out of sample error is, and why you made the choices you did. You will also use your prediction model to predict 20 different test cases.

Your submission for the Peer Review portion should consist of a link to a Github repo with your R markdown and compiled HTML file describing your analysis. Please constrain the text of the writeup to < 2000 words and the number of figures to be less than 5. It will make it easier for the graders if you submit a repo with a gh-pages branch so the HTML page can be viewed online (and you always want to make it easy on graders :-). Apply your machine learning algorithm to the 20 test cases available in the test data above and submit your predictions in appropriate format to the Course Project Prediction Quiz for automated grading.

Choosing the Prediction Model

Two models will be tested using decision tree and random forest algorithms. The model with the highest accuracy will be chosen as our final model.

```
library(caret)
```

```
## Warning: package 'caret' was built under R version 3.3.3
## Loading required package: lattice
## Loading required package: ggplot2
```

```
library(randomForest)
```

```
## Warning: package 'randomForest' was built under R version 3.3.3
## randomForest 4.6-12
## Type rfNews() to see new features/changes/bug fixes.
##
## Attaching package: 'randomForest'
## The following object is masked from 'package:ggplot2':
##
##     margin
```

```
library(rpart)
```

```
## Warning: package 'rpart' was built under R version 3.3.3
```

```
library(rpart.plot)
```

```
## Warning: package 'rpart.plot' was built under R version 3.3.3
```

Load Data

To remove the "#DIV/0!" data and replace with NA value.

```
trainingset <- read.csv("D:/R working file/Course 8 Practical Machine Learning/Week 4/pml-training.csv"
testingset <- read.csv("D:/R working file/Course 8 Practical Machine Learning/Week 4/pml-testing.csv",na
```

To check dimensions for number of variables and number of observations

```
dim(trainingset)
```

```
## [1] 19622   160
```

```
dim(testingset)
```

```
## [1]  20 160
```

To delete columns with all missing values

```
trainingset<-trainingset[,colSums(is.na(trainingset)) == 0]
testingset <-testingset[,colSums(is.na(testingset)) == 0]
```

To delete those irrelevant variables

```
trainingset   <-trainingset[,-c(1:7)]
testingset <-testingset[,-c(1:7)]
```

To look at the new datasets

```r
dim(trainingset)
```

```
## [1] 19622    53
```

```r
dim(testingset)
```

```
## [1] 20 53
```

```r
head(trainingset)
```

```
##   roll_belt pitch_belt yaw_belt total_accel_belt gyros_belt_x gyros_belt_y
## 1      1.41       8.07    -94.4                3         0.00         0.00
## 2      1.41       8.07    -94.4                3         0.02         0.00
## 3      1.42       8.07    -94.4                3         0.00         0.00
## 4      1.48       8.05    -94.4                3         0.02         0.00
## 5      1.48       8.07    -94.4                3         0.02         0.02
## 6      1.45       8.06    -94.4                3         0.02         0.00
##   gyros_belt_z accel_belt_x accel_belt_y accel_belt_z magnet_belt_x
## 1        -0.02          -21            4           22            -3
## 2        -0.02          -22            4           22            -7
## 3        -0.02          -20            5           23            -2
## 4        -0.03          -22            3           21            -6
## 5        -0.02          -21            2           24            -6
## 6        -0.02          -21            4           21             0
##   magnet_belt_y magnet_belt_z roll_arm pitch_arm yaw_arm total_accel_arm
## 1           599          -313     -128      22.5    -161              34
## 2           608          -311     -128      22.5    -161              34
## 3           600          -305     -128      22.5    -161              34
## 4           604          -310     -128      22.1    -161              34
## 5           600          -302     -128      22.1    -161              34
## 6           603          -312     -128      22.0    -161              34
##   gyros_arm_x gyros_arm_y gyros_arm_z accel_arm_x accel_arm_y accel_arm_z
## 1        0.00        0.00       -0.02        -288         109        -123
## 2        0.02       -0.02       -0.02        -290         110        -125
## 3        0.02       -0.02       -0.02        -289         110        -126
## 4        0.02       -0.03        0.02        -289         111        -123
## 5        0.00       -0.03        0.00        -289         111        -123
## 6        0.02       -0.03        0.00        -289         111        -122
##   magnet_arm_x magnet_arm_y magnet_arm_z roll_dumbbell pitch_dumbbell
## 1         -368          337          516      13.05217      -70.49400
## 2         -369          337          513      13.13074      -70.63751
## 3         -368          344          513      12.85075      -70.27812
## 4         -372          344          512      13.43120      -70.39379
## 5         -374          337          506      13.37872      -70.42856
## 6         -369          342          513      13.38246      -70.81759
##   yaw_dumbbell total_accel_dumbbell gyros_dumbbell_x gyros_dumbbell_y
## 1    -84.87394                   37                0            -0.02
## 2    -84.71065                   37                0            -0.02
## 3    -85.14078                   37                0            -0.02
## 4    -84.87363                   37                0            -0.02
## 5    -84.85306                   37                0            -0.02
## 6    -84.46500                   37                0            -0.02
##   gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y accel_dumbbell_z
## 1             0.00             -234               47             -271
```

```
## 2             0.00              -233              47              -269
## 3             0.00              -232              46              -270
## 4            -0.02              -232              48              -269
## 5             0.00              -233              48              -270
## 6             0.00              -234              48              -269
##   magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z roll_forearm
## 1              -559               293               -65         28.4
## 2              -555               296               -64         28.3
## 3              -561               298               -63         28.3
## 4              -552               303               -60         28.1
## 5              -554               292               -68         28.0
## 6              -558               294               -66         27.9
##   pitch_forearm yaw_forearm total_accel_forearm gyros_forearm_x
## 1         -63.9        -153                  36            0.03
## 2         -63.9        -153                  36            0.02
## 3         -63.9        -152                  36            0.03
## 4         -63.9        -152                  36            0.02
## 5         -63.9        -152                  36            0.02
## 6         -63.9        -152                  36            0.02
##   gyros_forearm_y gyros_forearm_z accel_forearm_x accel_forearm_y
## 1            0.00           -0.02             192             203
## 2            0.00           -0.02             192             203
## 3           -0.02            0.00             196             204
## 4           -0.02            0.00             189             206
## 5            0.00           -0.02             189             206
## 6           -0.02           -0.03             193             203
##   accel_forearm_z magnet_forearm_x magnet_forearm_y magnet_forearm_z
## 1            -215              -17              654              476
## 2            -216              -18              661              473
## 3            -213              -18              658              469
## 4            -214              -16              658              469
## 5            -214              -17              655              473
## 6            -215               -9              660              478
##   classe
## 1      A
## 2      A
## 3      A
## 4      A
## 5      A
## 6      A
```

```r
head(testingset)
```

```
##   roll_belt pitch_belt yaw_belt total_accel_belt gyros_belt_x gyros_belt_y
## 1    123.00      27.00    -4.75               20        -0.50        -0.02
## 2      1.02       4.87   -88.90                4        -0.06        -0.02
## 3      0.87       1.82   -88.50                5         0.05         0.02
## 4    125.00     -41.60   162.00               17         0.11         0.11
## 5      1.35       3.33   -88.60                3         0.03         0.02
## 6     -5.92       1.59   -87.70                4         0.10         0.05
##   gyros_belt_z accel_belt_x accel_belt_y accel_belt_z magnet_belt_x
## 1        -0.46          -38           69         -179           -13
## 2        -0.07          -13           11           39            43
## 3         0.03            1           -1           49            29
## 4        -0.16           46           45         -156           169
```

```
## 5        0.00           -8            4           27            33
## 6       -0.13          -11          -16           38            31
##   magnet_belt_y magnet_belt_z roll_arm pitch_arm yaw_arm total_accel_arm
## 1           581          -382     40.7    -27.80     178              10
## 2           636          -309      0.0      0.00       0              38
## 3           631          -312      0.0      0.00       0              44
## 4           608          -304   -109.0     55.00    -142              25
## 5           566          -418     76.1      2.76     102              29
## 6           638          -291      0.0      0.00       0              14
##   gyros_arm_x gyros_arm_y gyros_arm_z accel_arm_x accel_arm_y accel_arm_z
## 1       -1.65        0.48       -0.18          16          38          93
## 2       -1.17        0.85       -0.43        -290         215         -90
## 3        2.10       -1.36        1.13        -341         245         -87
## 4        0.22       -0.51        0.92        -238         -57           6
## 5       -1.96        0.79       -0.54        -197         200         -30
## 6        0.02        0.05       -0.07         -26         130         -19
##   magnet_arm_x magnet_arm_y magnet_arm_z roll_dumbbell pitch_dumbbell
## 1         -326          385          481     -17.73748       24.96085
## 2         -325          447          434      54.47761      -53.69758
## 3         -264          474          413      57.07031      -51.37303
## 4         -173          257          633      43.10927      -30.04885
## 5         -170          275          617    -101.38396      -53.43952
## 6          396          176          516      62.18750      -50.55595
##   yaw_dumbbell total_accel_dumbbell gyros_dumbbell_x gyros_dumbbell_y
## 1    126.23596                    9             0.64             0.06
## 2    -75.51480                   31             0.34             0.05
## 3    -75.20287                   29             0.39             0.14
## 4   -103.32003                   18             0.10            -0.02
## 5    -14.19542                    4             0.29            -0.47
## 6    -71.12063                   29            -0.59             0.80
##   gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y accel_dumbbell_z
## 1            -0.61               21              -15               81
## 2            -0.71             -153              155             -205
## 3            -0.34             -141              155             -196
## 4             0.05              -51               72             -148
## 5            -0.46              -18              -30               -5
## 6             1.10             -138              166             -186
##   magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z roll_forearm
## 1               523              -528               -56          141
## 2              -502               388               -36          109
## 3              -506               349                41          131
## 4              -576               238                53            0
## 5              -424               252               312         -176
## 6              -543               262                96          150
##   pitch_forearm yaw_forearm total_accel_forearm gyros_forearm_x
## 1         49.30       156.0                  33            0.74
## 2        -17.60       106.0                  39            1.12
## 3        -32.60        93.0                  34            0.18
## 4          0.00         0.0                  43            1.38
## 5         -2.16       -47.9                  24           -0.75
## 6          1.46        89.7                  43           -0.88
##   gyros_forearm_y gyros_forearm_z accel_forearm_x accel_forearm_y
## 1           -3.34           -0.59            -110             267
## 2           -2.78           -0.18             212             297
```

```
## 3           -0.79           0.28             154             271
## 4            0.69           1.80             -92             406
## 5            3.10           0.80             131             -93
## 6            4.26           1.35             230             322
##   accel_forearm_z magnet_forearm_x magnet_forearm_y magnet_forearm_z
## 1            -149             -714              419              617
## 2            -118             -237              791              873
## 3            -129              -51              698              783
## 4             -39             -233              783              521
## 5             172              375             -787               91
## 6            -144             -300              800              884
##   problem_id
## 1          1
## 2          2
## 3          3
## 4          4
## 5          5
## 6          6
```

Partitioning Training Data Set

In order to perform cross-validation, the training data set is partionned into 2 sets: subTraining (75%) and subTest (25%). This will be performed using random subsampling without replacement.

```r
subsamples <- createDataPartition(y=trainingset$classe, p=0.75, list=FALSE)
subTraining <- trainingset[subsamples, ]
subTesting <- trainingset[-subsamples, ]
dim(subTraining)
```

```
## [1] 14718    53
```

```r
dim(subTesting)
```

```
## [1] 4904   53
```

```r
head(subTraining)
```

```
##    roll_belt pitch_belt yaw_belt total_accel_belt gyros_belt_x
## 3       1.42       8.07    -94.4                3         0.00
## 6       1.45       8.06    -94.4                3         0.02
## 7       1.42       8.09    -94.4                3         0.02
## 8       1.42       8.13    -94.4                3         0.02
## 10      1.45       8.17    -94.4                3         0.03
## 12      1.43       8.18    -94.4                3         0.02
##    gyros_belt_y gyros_belt_z accel_belt_x accel_belt_y accel_belt_z
## 3             0        -0.02          -20            5           23
## 6             0        -0.02          -21            4           21
## 7             0        -0.02          -22            3           21
## 8             0        -0.02          -22            4           21
## 10            0         0.00          -21            4           22
## 12            0        -0.02          -22            2           23
##    magnet_belt_x magnet_belt_y magnet_belt_z roll_arm pitch_arm yaw_arm
## 3             -2           600          -305     -128      22.5    -161
## 6              0           603          -312     -128      22.0    -161
## 7             -4           599          -311     -128      21.9    -161
```

```
## 8            -2           603          -313     -128      21.8    -161
## 10           -3           609          -308     -128      21.6    -161
## 12           -2           602          -319     -128      21.5    -161
##    total_accel_arm gyros_arm_x gyros_arm_y gyros_arm_z accel_arm_x
## 3               34        0.02       -0.02       -0.02        -289
## 6               34        0.02       -0.03        0.00        -289
## 7               34        0.00       -0.03        0.00        -289
## 8               34        0.02       -0.02        0.00        -289
## 10              34        0.02       -0.03       -0.02        -288
## 12              34        0.02       -0.03        0.00        -288
##    accel_arm_y accel_arm_z magnet_arm_x magnet_arm_y magnet_arm_z
## 3          110        -126         -368          344          513
## 6          111        -122         -369          342          513
## 7          111        -125         -373          336          509
## 8          111        -124         -372          338          510
## 10         110        -124         -376          334          516
## 12         111        -123         -363          343          520
##    roll_dumbbell pitch_dumbbell yaw_dumbbell total_accel_dumbbell
## 3       12.85075      -70.27812    -85.14078                   37
## 6       13.38246      -70.81759    -84.46500                   37
## 7       13.12695      -70.24757    -85.09961                   37
## 8       12.75083      -70.34768    -85.09708                   37
## 10      13.33034      -70.85059    -84.44602                   37
## 12      13.10321      -70.45975    -84.89472                   37
##    gyros_dumbbell_x gyros_dumbbell_y gyros_dumbbell_z accel_dumbbell_x
## 3                 0            -0.02                0             -232
## 6                 0            -0.02                0             -234
## 7                 0            -0.02                0             -232
## 8                 0            -0.02                0             -234
## 10                0            -0.02                0             -235
## 12                0            -0.02                0             -233
##    accel_dumbbell_y accel_dumbbell_z magnet_dumbbell_x magnet_dumbbell_y
## 3                46             -270              -561               298
## 6                48             -269              -558               294
## 7                47             -270              -551               295
## 8                46             -272              -555               300
## 10               48             -270              -558               291
## 12               47             -270              -554               291
##    magnet_dumbbell_z roll_forearm pitch_forearm yaw_forearm
## 3                -63         28.3         -63.9        -152
## 6                -66         27.9         -63.9        -152
## 7                -70         27.9         -63.9        -152
## 8                -74         27.8         -63.8        -152
## 10               -69         27.7         -63.8        -152
## 12               -65         27.5         -63.8        -152
##    total_accel_forearm gyros_forearm_x gyros_forearm_y gyros_forearm_z
## 3                   36            0.03           -0.02            0.00
## 6                   36            0.02           -0.02           -0.03
## 7                   36            0.02            0.00           -0.02
## 8                   36            0.02           -0.02            0.00
## 10                  36            0.02            0.00           -0.02
## 12                  36            0.02            0.02           -0.03
##    accel_forearm_x accel_forearm_y accel_forearm_z magnet_forearm_x
## 3              196             204            -213              -18
```

```
## 6              193              203            -215              -9
## 7              195              205            -215             -18
## 8              193              205            -213              -9
## 10             190              205            -215             -22
## 12             191              203            -215             -11
##    magnet_forearm_y magnet_forearm_z classe
## 3               658              469      A
## 6               660              478      A
## 7               659              470      A
## 8               660              474      A
## 10              656              473      A
## 12              657              478      A
```

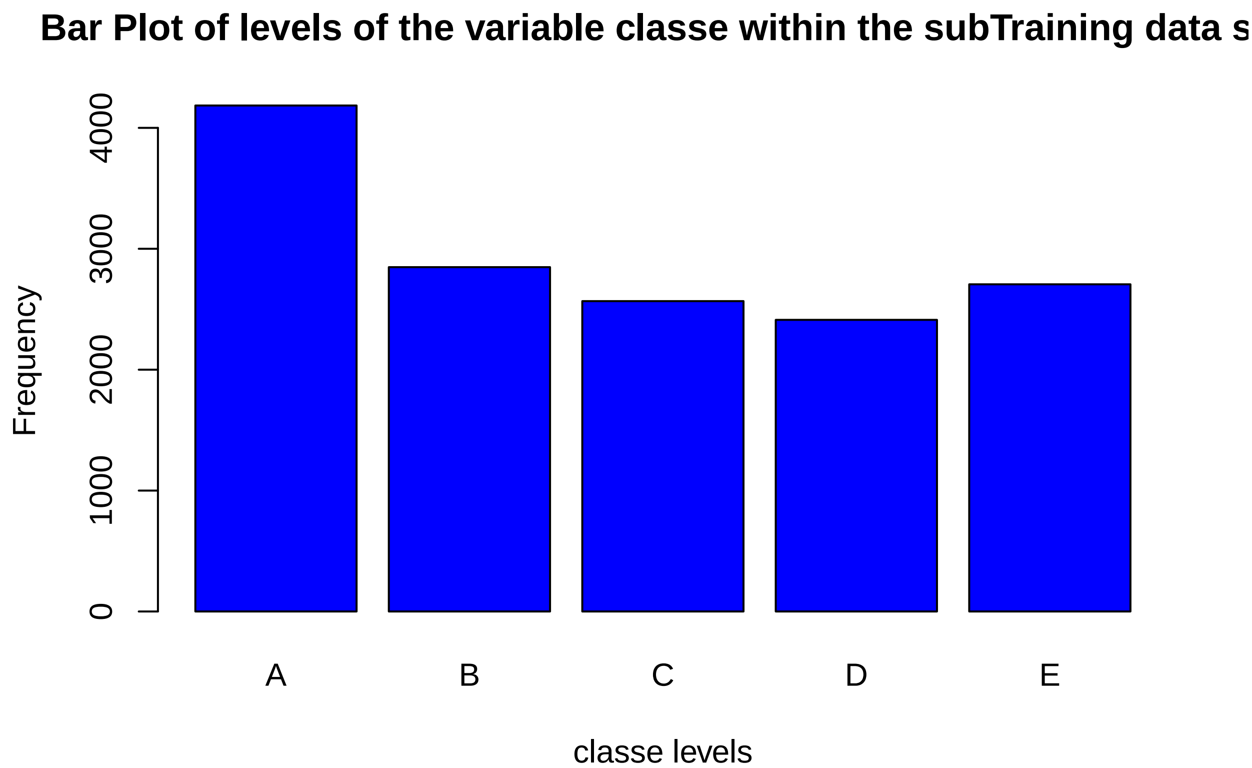
```r
head(subTesting)
```

```
##    roll_belt pitch_belt yaw_belt total_accel_belt gyros_belt_x
## 1       1.41       8.07    -94.4                3         0.00
## 2       1.41       8.07    -94.4                3         0.02
## 4       1.48       8.05    -94.4                3         0.02
## 5       1.48       8.07    -94.4                3         0.02
## 9       1.43       8.16    -94.4                3         0.02
## 11      1.45       8.18    -94.4                3         0.03
##    gyros_belt_y gyros_belt_z accel_belt_x accel_belt_y accel_belt_z
## 1          0.00        -0.02          -21            4           22
## 2          0.00        -0.02          -22            4           22
## 4          0.00        -0.03          -22            3           21
## 5          0.02        -0.02          -21            2           24
## 9          0.00        -0.02          -20            2           24
## 11         0.00        -0.02          -21            2           23
##    magnet_belt_x magnet_belt_y magnet_belt_z roll_arm pitch_arm yaw_arm
## 1             -3           599          -313     -128      22.5    -161
## 2             -7           608          -311     -128      22.5    -161
## 4             -6           604          -310     -128      22.1    -161
## 5             -6           600          -302     -128      22.1    -161
## 9              1           602          -312     -128      21.7    -161
## 11            -5           596          -317     -128      21.5    -161
##    total_accel_arm gyros_arm_x gyros_arm_y gyros_arm_z accel_arm_x
## 1               34        0.00        0.00       -0.02        -288
## 2               34        0.02       -0.02       -0.02        -290
## 4               34        0.02       -0.03        0.02        -289
## 5               34        0.00       -0.03        0.00        -289
## 9               34        0.02       -0.03       -0.02        -288
## 11              34        0.02       -0.03        0.00        -290
##    accel_arm_y accel_arm_z magnet_arm_x magnet_arm_y magnet_arm_z
## 1          109        -123         -368          337          516
## 2          110        -125         -369          337          513
## 4          111        -123         -372          344          512
## 5          111        -123         -374          337          506
## 9          109        -122         -369          341          518
## 11         110        -123         -366          339          509
##    roll_dumbbell pitch_dumbbell yaw_dumbbell total_accel_dumbbell
## 1       13.05217      -70.49400    -84.87394                   37
## 2       13.13074      -70.63751    -84.71065                   37
## 4       13.43120      -70.39379    -84.87363                   37
## 5       13.37872      -70.42856    -84.85306                   37
```

```
## 9       13.15463      -70.42520    -84.91563                   37
## 11      13.13074      -70.63751    -84.71065                   37
##    gyros_dumbbell_x gyros_dumbbell_y gyros_dumbbell_z accel_dumbbell_x
## 1                 0            -0.02             0.00             -234
## 2                 0            -0.02             0.00             -233
## 4                 0            -0.02            -0.02             -232
## 5                 0            -0.02             0.00             -233
## 9                 0            -0.02             0.00             -232
## 11                0            -0.02             0.00             -233
##    accel_dumbbell_y accel_dumbbell_z magnet_dumbbell_x magnet_dumbbell_y
## 1                47             -271              -559               293
## 2                47             -269              -555               296
## 4                48             -269              -552               303
## 5                48             -270              -554               292
## 9                47             -269              -549               292
## 11               47             -269              -564               299
##    magnet_dumbbell_z roll_forearm pitch_forearm yaw_forearm
## 1                -65         28.4         -63.9        -153
## 2                -64         28.3         -63.9        -153
## 4                -60         28.1         -63.9        -152
## 5                -68         28.0         -63.9        -152
## 9                -65         27.7         -63.8        -152
## 11               -64         27.6         -63.8        -152
##    total_accel_forearm gyros_forearm_x gyros_forearm_y gyros_forearm_z
## 1                   36            0.03            0.00           -0.02
## 2                   36            0.02            0.00           -0.02
## 4                   36            0.02           -0.02            0.00
## 5                   36            0.02            0.00           -0.02
## 9                   36            0.03            0.00           -0.02
## 11                  36            0.02           -0.02           -0.02
##    accel_forearm_x accel_forearm_y accel_forearm_z magnet_forearm_x
## 1              192             203            -215              -17
## 2              192             203            -216              -18
## 4              189             206            -214              -16
## 5              189             206            -214              -17
## 9              193             204            -214              -16
## 11             193             205            -214              -17
##    magnet_forearm_y magnet_forearm_z classe
## 1               654              476      A
## 2               661              473      A
## 4               658              469      A
## 5               655              473      A
## 9               653              476      A
## 11              657              465      A
```

Plot a Bar Plot

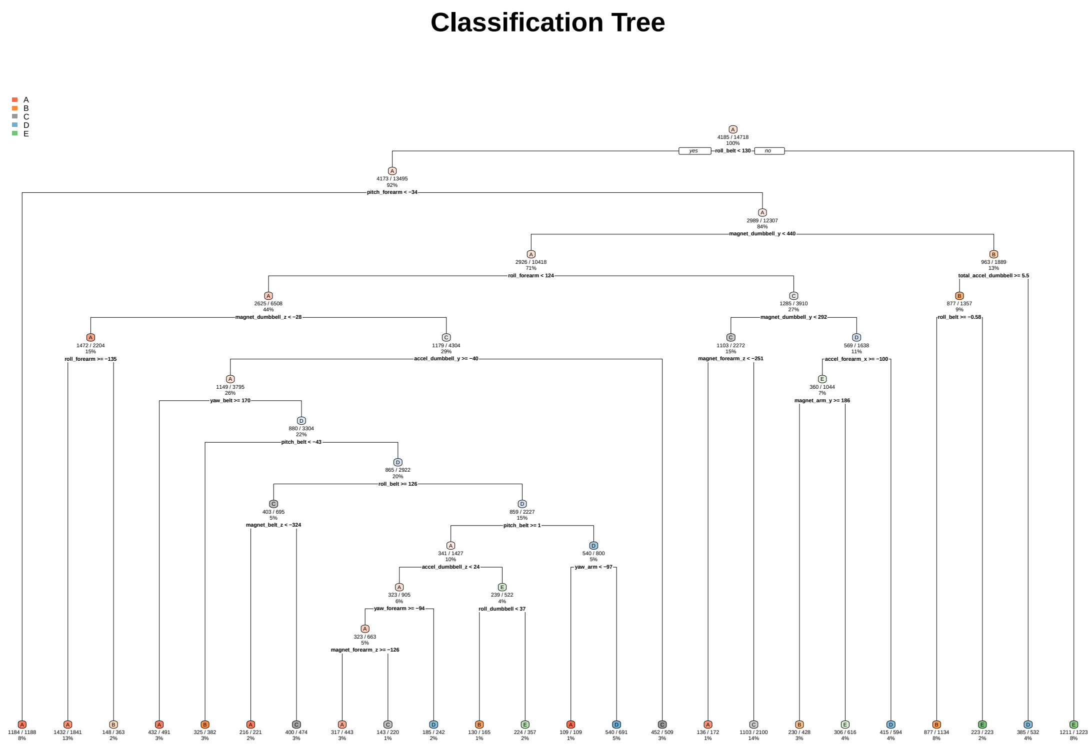
```
plot(subTraining$classe, col="blue", main="Bar Plot of levels of the variable classe within the subTrai
```



Level A is the most frequent occurrences while level D is the least frequent occurrences.

First Prediction : Using Decision Tree

```
model1 <- rpart(classe ~ ., data=subTraining, method="class")
prediction1 <- predict(model1, subTesting, type = "class")
rpart.plot(model1, main="Classification Tree", extra=102, under=TRUE, faclen=0)
```




```r
confusionMatrix(prediction1, subTesting$classe)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1268  131    9   39   17
##          B   42  560   81   69   81
##          C   39  139  695  132  115
##          D   18   67   52  499   49
##          E   28   52   18   65  639
##
## Overall Statistics
##
##                Accuracy : 0.7465
##                  95% CI : (0.7341, 0.7587)
##     No Information Rate : 0.2845
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.6789
##  Mcnemar's Test P-Value : < 2.2e-16
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.9090   0.5901   0.8129   0.6206   0.7092
```

```
## Specificity            0.9441   0.9310   0.8950   0.9546   0.9593
## Pos Pred Value         0.8661   0.6723   0.6205   0.7285   0.7968
## Neg Pred Value         0.9631   0.9044   0.9577   0.9277   0.9361
## Prevalence             0.2845   0.1935   0.1743   0.1639   0.1837
## Detection Rate         0.2586   0.1142   0.1417   0.1018   0.1303
## Detection Prevalence   0.2985   0.1699   0.2284   0.1397   0.1635
## Balanced Accuracy      0.9266   0.7605   0.8540   0.7876   0.8342
```

Second Prediction : Using Random Forest

```
model2 <- randomForest(classe ~. , data=subTraining, method="class")
prediction2 <- predict(model2, subTesting, type = "class")
confusionMatrix(prediction2, subTesting$classe)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1394    1    0    0    0
##          B    0  945    7    0    0
##          C    0    3  846    8    1
##          D    0    0    2  795    0
##          E    1    0    0    1  900
##
## Overall Statistics
##
##                Accuracy : 0.9951
##                  95% CI : (0.9927, 0.9969)
##     No Information Rate : 0.2845
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.9938
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.9993   0.9958   0.9895   0.9888   0.9989
## Specificity            0.9997   0.9982   0.9970   0.9995   0.9995
## Pos Pred Value         0.9993   0.9926   0.9860   0.9975   0.9978
## Neg Pred Value         0.9997   0.9990   0.9978   0.9978   0.9998
## Prevalence             0.2845   0.1935   0.1743   0.1639   0.1837
## Detection Rate         0.2843   0.1927   0.1725   0.1621   0.1835
## Detection Prevalence   0.2845   0.1941   0.1750   0.1625   0.1839
## Balanced Accuracy      0.9995   0.9970   0.9933   0.9942   0.9992
```

Decision

Random Forest algorithm performed better than Decision Trees.Accuracy for Random Forest model was 0.991 (95% CI: (0.9884, 0.9938)) compared to 0.664 (95% CI: (0.6509, 0.6776)) for Decision Tree model. The random Forest model is choosen. The accuracy of the model is 0.991. The expected out-of-sample error is estimated at 0.005, or 0.5%. The expected out-of-sample error is calculated as 1 - accuracy for predictions made against the cross-validation set. Our Test data set comprises 20 cases. With an accuracy above 99% on our cross-validation data, we can expect that very few, or none, of the test samples will be missclassified.