

Assignment for Machine Learning

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1. Synopsis

In this assignment I will evaluate personal training data. We will try to predict how well any given exercise has been done by the user. This information is in the “classe” variable. I will try to predict this variable.

2. Getting acquainted with the data

The training and testing data is read into R using the read.csv function

```
training <- read.csv("pml-training.csv")
```

2.1. General Characteristics

Checking the dimension, variable names and the possible outcomes

```
dim(training)
```

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

```
names(training)
```

```

## [1] "X"                               "user_name"
## [3] "raw_timestamp_part_1"             "raw_timestamp_part_2"
## [5] "cvtd_timestamp"                  "new_window"
## [7] "num_window"                     "roll_belt"
## [9] "pitch_belt"                     "yaw_belt"
## [11] "total_accel_belt"               "kurtosis_roll_belt"
## [13] "kurtosis_pitch_belt"            "kurtosis_yaw_belt"
## [15] "skewness_roll_belt"              "skewness_roll_belt.1"
## [17] "skewness_yaw_belt"              "max_roll_belt"
## [19] "max_pitch_belt"                "max_yaw_belt"
## [21] "min_roll_belt"                 "min_pitch_belt"
## [23] "min_yaw_belt"                  "amplitude_roll_belt"
## [25] "amplitude_pitch_belt"           "amplitude_yaw_belt"
## [27] "var_total_accel_belt"            "avg_roll_belt"
## [29] "stddev_roll_belt"               "var_roll_belt"
## [31] "avg_pitch_belt"                 "stddev_pitch_belt"
## [33] "var_pitch_belt"                 "avg_yaw_belt"
## [35] "stddev_yaw_belt"                "var_yaw_belt"
## [37] "gyros_belt_x"                   "gyros_belt_y"
## [39] "gyros_belt_z"                   "accel_belt_x"
## [41] "accel_belt_y"                   "accel_belt_z"
## [43] "magnet_belt_x"                  "magnet_belt_y"
## [45] "magnet_belt_z"                  "roll_arm"
## [47] "pitch_arm"                      "yaw_arm"
## [49] "total_accel_arm"                "var_accel_arm"
## [51] "avg_roll_arm"                   "stddev_roll_arm"
## [53] "var_roll_arm"                   "avg_pitch_arm"
## [55] "stddev_pitch_arm"               "var_pitch_arm"
## [57] "avg_yaw_arm"                   "stddev_yaw_arm"
## [59] "var_yaw_arm"                    "gyros_arm_x"
## [61] "gyros_arm_y"                   "gyros_arm_z"
## [63] "accel_arm_x"                   "accel_arm_y"
## [65] "accel_arm_z"                   "magnet_arm_x"
## [67] "magnet_arm_y"                  "magnet_arm_z"
## [69] "kurtosis_roll_arm"              "kurtosis_pitch_arm"
## [71] "kurtosis_yaw_arm"               "skewness_roll_arm"
## [73] "skewness_pitch_arm"              "skewness_yaw_arm"
## [75] "max_roll_arm"                  "max_pitch_arm"
## [77] "max_yaw_arm"                   "min_roll_arm"
## [79] "min_pitch_arm"                 "min_yaw_arm"
## [81] "amplitude_roll_arm"              "amplitude_pitch_arm"
## [83] "amplitude_yaw_arm"              "roll_dumbbell"
## [85] "pitch_dumbbell"                 "yaw_dumbbell"
## [87] "kurtosis_roll_dumbbell"          "kurtosis_pitch_dumbbell"
## [89] "kurtosis_yaw_dumbbell"            "skewness_roll_dumbbell"
## [91] "skewness_pitch_dumbbell"          "skewness_yaw_dumbbell"
## [93] "max_roll_dumbbell"               "max_pitch_dumbbell"
## [95] "max_yaw_dumbbell"                "min_roll_dumbbell"
## [97] "min_pitch_dumbbell"              "min_yaw_dumbbell"
## [99] "amplitude_roll_dumbbell"          "amplitude_pitch_dumbbell"
## [101] "amplitude_yaw_dumbbell"          "total_accel_dumbbell"
## [103] "var_accel_dumbbell"              "avg_roll_dumbbell"
## [105] "stddev_roll_dumbbell"             "var_roll_dumbbell"
## [107] "avg_pitch_dumbbell"              "stddev_pitch_dumbbell"
## [109] "var_pitch_dumbbell"              "avg_yaw_dumbbell"
## [111] "stddev_yaw_dumbbell"              "var_yaw_dumbbell"
## [113] "gyros_dumbbell_x"                "gyros_dumbbell_y"

```

```

## [115] "gyros_dumbbell_z"
## [117] "accel_dumbbell_y"
## [119] "magnet_dumbbell_x"
## [121] "magnet_dumbbell_z"
## [123] "pitch_forearm"
## [125] "kurtosis_roll_forearm"
## [127] "kurtosis_yaw_forearm"
## [129] "skewness_pitch_forearm"
## [131] "max_roll_forearm"
## [133] "max_yaw_forearm"
## [135] "min_pitch_forearm"
## [137] "amplitude_roll_forearm"
## [139] "amplitude_yaw_forearm"
## [141] "var_accel_forearm"
## [143] "stddev_roll_forearm"
## [145] "avg_pitch_forearm"
## [147] "var_pitch_forearm"
## [149] "stddev_yaw_forearm"
## [151] "gyros_forearm_x"
## [153] "gyros_forearm_z"
## [155] "accel_forearm_y"
## [157] "magnet_forearm_x"
## [159] "magnet_forearm_z"

## accel_dumbbell_x"
## accel_dumbbell_z"
## magnet_dumbbell_y"
## roll_forearm"
## yaw_forearm"
## kurtosis_pitch_forearm"
## skewness_roll_forearm"
## skewness_yaw_forearm"
## max_pitch_forearm"
## min_roll_forearm"
## min_yaw_forearm"
## amplitude_pitch_forearm"
## total_accel_forearm"
## avg_roll_forearm"
## var_roll_forearm"
## stddev_pitch_forearm"
## avg_yaw_forearm"
## var_yaw_forearm"
## gyros_forearm_y"
## accel_forearm_x"
## accel_forearm_z"
## magnet_forearm_y"
## classe"

```

```
summary(training$classe)
```

```

##      A      B      C      D      E
## 5580 3797 3422 3216 3607

```

So we have 159 predictors and we try to predict a factor variable with 5 different outcome possibilities.

I will delete the first 7 columns since these are not needed for our model (observation number, user name, timestamps, etc)

```

training <- training[,-(1:7)]
head(training)

```

```

##   roll_belt pitch_belt yaw_belt total_accel_belt kurtosis_roll_belt
## 1     1.41     8.07 -94.4          3
## 2     1.41     8.07 -94.4          3
## 3     1.42     8.07 -94.4          3
## 4     1.48     8.05 -94.4          3
## 5     1.48     8.07 -94.4          3
## 6     1.45     8.06 -94.4          3
##   kurtosis_pictch_belt kurtosis_yaw_belt skewness_roll_belt
## 1
## 2
## 3
## 4
## 5
## 6
##   skewness_roll_belt.1 skewness_yaw_belt max_roll_belt max_pictch_belt
## 1                               NA      NA
## 2                               NA      NA
## 3                               NA      NA
## 4                               NA      NA
## 5                               NA      NA
## 6                               NA      NA
##   max_yaw_belt min_roll_belt min_pitch_belt min_yaw_belt
## 1             NA      NA
## 2             NA      NA
## 3             NA      NA
## 4             NA      NA
## 5             NA      NA
## 6             NA      NA
##   amplitude_roll_belt amplitude_pitch_belt amplitude_yaw_belt
## 1             NA      NA
## 2             NA      NA
## 3             NA      NA
## 4             NA      NA
## 5             NA      NA
## 6             NA      NA
##   var_total_accel_belt avg_roll_belt stddev_roll_belt var_roll_belt
## 1             NA      NA      NA      NA
## 2             NA      NA      NA      NA
## 3             NA      NA      NA      NA
## 4             NA      NA      NA      NA
## 5             NA      NA      NA      NA
## 6             NA      NA      NA      NA
##   avg_pitch_belt stddev_pitch_belt var_pitch_belt avg_yaw_belt
## 1             NA      NA      NA      NA
## 2             NA      NA      NA      NA
## 3             NA      NA      NA      NA
## 4             NA      NA      NA      NA
## 5             NA      NA      NA      NA
## 6             NA      NA      NA      NA
##   stddev_yaw_belt var_yaw_belt gyros_belt_x gyros_belt_y gyros_belt_z
## 1             NA      NA     0.00     0.00    -0.02
## 2             NA      NA     0.02     0.00    -0.02
## 3             NA      NA     0.00     0.00    -0.02
## 4             NA      NA     0.02     0.00    -0.03
## 5             NA      NA     0.02     0.02    -0.02
## 6             NA      NA     0.02     0.00    -0.02
##   accel_belt_x accel_belt_y accel_belt_z magnet_belt_x magnet_belt_y

```

```

## 1      -21       4     22      -3      599
## 2      -22       4     22      -7      608
## 3      -20       5     23      -2      600
## 4      -22       3     21      -6      604
## 5      -21       2     24      -6      600
## 6      -21       4     21       0      603
## magnet_belt_z roll_arm pitch_arm yaw_arm total_accel_arm var_accel_arm
## 1      -313    -128   22.5   -161      34      NA
## 2      -311    -128   22.5   -161      34      NA
## 3      -305    -128   22.5   -161      34      NA
## 4      -310    -128   22.1   -161      34      NA
## 5      -302    -128   22.1   -161      34      NA
## 6      -312    -128   22.0   -161      34      NA
## avg_roll_arm stddev_roll_arm var_roll_arm avg_pitch_arm stddev_pitch_arm
## 1        NA        NA        NA        NA      NA
## 2        NA        NA        NA        NA      NA
## 3        NA        NA        NA        NA      NA
## 4        NA        NA        NA        NA      NA
## 5        NA        NA        NA        NA      NA
## 6        NA        NA        NA        NA      NA
## var_pitch_arm avg_yaw_arm stddev_yaw_arm var_yaw_arm gyros_arm_x
## 1        NA        NA        NA        NA     0.00
## 2        NA        NA        NA        NA     0.02
## 3        NA        NA        NA        NA     0.02
## 4        NA        NA        NA        NA     0.02
## 5        NA        NA        NA        NA     0.00
## 6        NA        NA        NA        NA     0.02
## gyros_arm_y gyros_arm_z accel_arm_x accel_arm_y accel_arm_z magnet_arm_x
## 1      0.00    -0.02    -288     109    -123    -368
## 2     -0.02    -0.02    -290     110    -125    -369
## 3     -0.02    -0.02    -289     110    -126    -368
## 4     -0.03     0.02    -289     111    -123    -372
## 5     -0.03     0.00    -289     111    -123    -374
## 6     -0.03     0.00    -289     111    -122    -369
## magnet_arm_y magnet_arm_z kurtosis_roll_arm kurtosis_pictch_arm
## 1      337      516
## 2      337      513
## 3      344      513
## 4      344      512
## 5      337      506
## 6      342      513
## kurtosis_yaw_arm skewness_roll_arm skewness_pitch_arm skewness_yaw_arm
## 1
## 2
## 3
## 4
## 5
## 6
## max_roll_arm max_picth_arm max_yaw_arm min_roll_arm min_pitch_arm
## 1        NA        NA        NA        NA      NA
## 2        NA        NA        NA        NA      NA
## 3        NA        NA        NA        NA      NA
## 4        NA        NA        NA        NA      NA
## 5        NA        NA        NA        NA      NA
## 6        NA        NA        NA        NA      NA
## min_yaw_arm amplitude_roll_arm amplitude_pitch_arm amplitude_yaw_arm
## 1        NA        NA        NA        NA      NA
## 2        NA        NA        NA        NA      NA

```

```

## 3      NA          NA          NA          NA
## 4      NA          NA          NA          NA
## 5      NA          NA          NA          NA
## 6      NA          NA          NA          NA
##   roll_dumbbell pitch_dumbbell yaw_dumbbell kurtosis_roll_dumbbell
## 1    13.05217    -70.49400   -84.87394
## 2    13.13074    -70.63751   -84.71065
## 3    12.85075    -70.27812   -85.14078
## 4    13.43120    -70.39379   -84.87363
## 5    13.37872    -70.42856   -84.85306
## 6    13.38246    -70.81759   -84.46500
##   kurtosis_pitch_dumbbell kurtosis_yaw_dumbbell skewness_roll_dumbbell
## 1
## 2
## 3
## 4
## 5
## 6
##   skewness_pitch_dumbbell skewness_yaw_dumbbell max_roll_dumbbell
## 1                               NA
## 2                               NA
## 3                               NA
## 4                               NA
## 5                               NA
## 6                               NA
##   max_pitch_dumbbell max_yaw_dumbbell min_roll_dumbbell min_pitch_dumbbell
## 1           NA          NA          NA          NA
## 2           NA          NA          NA          NA
## 3           NA          NA          NA          NA
## 4           NA          NA          NA          NA
## 5           NA          NA          NA          NA
## 6           NA          NA          NA          NA
##   min_yaw_dumbbell amplitude_roll_dumbbell amplitude_pitch_dumbbell
## 1           NA          NA          NA
## 2           NA          NA          NA
## 3           NA          NA          NA
## 4           NA          NA          NA
## 5           NA          NA          NA
## 6           NA          NA          NA
##   amplitude_yaw_dumbbell total_accel_dumbbell var_accel_dumbbell
## 1           37          NA          NA
## 2           37          NA          NA
## 3           37          NA          NA
## 4           37          NA          NA
## 5           37          NA          NA
## 6           37          NA          NA
##   avg_roll_dumbbell stddev_roll_dumbbell var_roll_dumbbell
## 1           NA          NA          NA
## 2           NA          NA          NA
## 3           NA          NA          NA
## 4           NA          NA          NA
## 5           NA          NA          NA
## 6           NA          NA          NA
##   avg_pitch_dumbbell stddev_pitch_dumbbell var_pitch_dumbbell
## 1           NA          NA          NA
## 2           NA          NA          NA
## 3           NA          NA          NA
## 4           NA          NA          NA

```

```

## 5          NA          NA          NA
## 6          NA          NA          NA
## avg_yaw_dumbbell stddev_yaw_dumbbell var_yaw_dumbbell gyros_dumbbell_x
## 1          NA          NA          NA          0
## 2          NA          NA          NA          0
## 3          NA          NA          NA          0
## 4          NA          NA          NA          0
## 5          NA          NA          NA          0
## 6          NA          NA          NA          0
## gyros_dumbbell_y gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y
## 1      -0.02      0.00     -234        47
## 2      -0.02      0.00     -233        47
## 3      -0.02      0.00     -232        46
## 4      -0.02     -0.02     -232        48
## 5      -0.02      0.00     -233        48
## 6      -0.02      0.00     -234        48
## accel_dumbbell_z magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z
## 1      -271      -559       293       -65
## 2      -269      -555       296       -64
## 3      -270      -561       298       -63
## 4      -269      -552       303       -60
## 5      -270      -554       292       -68
## 6      -269      -558       294       -66
## roll_forearm pitch_forearm yaw_forearm kurtosis_roll_forearm
## 1      28.4     -63.9     -153
## 2      28.3     -63.9     -153
## 3      28.3     -63.9     -152
## 4      28.1     -63.9     -152
## 5      28.0     -63.9     -152
## 6      27.9     -63.9     -152
## kurtosis_pictch_forearm kurtosis_yaw_forearm skewness_roll_forearm
## 1
## 2
## 3
## 4
## 5
## 6
## skewness_pitch_forearm skewness_yaw_forearm max_roll_forearm
## 1                           NA
## 2                           NA
## 3                           NA
## 4                           NA
## 5                           NA
## 6                           NA
## max_pictch_forearm max_yaw_forearm min_roll_forearm min_pitch_forearm
## 1          NA          NA          NA
## 2          NA          NA          NA
## 3          NA          NA          NA
## 4          NA          NA          NA
## 5          NA          NA          NA
## 6          NA          NA          NA
## min_yaw_forearm amplitude_roll_forearm amplitude_pitch_forearm
## 1          NA          NA          NA
## 2          NA          NA          NA
## 3          NA          NA          NA
## 4          NA          NA          NA
## 5          NA          NA          NA
## 6          NA          NA          NA

```

```

##  amplitude_yaw_forearm total_accel_forearm var_accel_forearm
## 1                      36                  NA
## 2                      36                  NA
## 3                      36                  NA
## 4                      36                  NA
## 5                      36                  NA
## 6                      36                  NA
## avg_roll_forearm stddev_roll_forearm var_roll_forearm avg_pitch_forearm
## 1          NA          NA          NA          NA
## 2          NA          NA          NA          NA
## 3          NA          NA          NA          NA
## 4          NA          NA          NA          NA
## 5          NA          NA          NA          NA
## 6          NA          NA          NA          NA
## stddev_pitch_forearm var_pitch_forearm avg_yaw_forearm
## 1          NA          NA          NA
## 2          NA          NA          NA
## 3          NA          NA          NA
## 4          NA          NA          NA
## 5          NA          NA          NA
## 6          NA          NA          NA
## stddev_yaw_forearm var_yaw_forearm gyros_forearm_x gyros_forearm_y
## 1          NA          NA      0.03      0.00
## 2          NA          NA      0.02      0.00
## 3          NA          NA      0.03     -0.02
## 4          NA          NA      0.02     -0.02
## 5          NA          NA      0.02      0.00
## 6          NA          NA      0.02     -0.02
## gyros_forearm_z accel_forearm_x accel_forearm_y accel_forearm_z
## 1      -0.02      192      203     -215
## 2      -0.02      192      203     -216
## 3       0.00      196      204     -213
## 4       0.00      189      206     -214
## 5      -0.02      189      206     -214
## 6      -0.03      193      203     -215
## magnet_forearm_x magnet_forearm_y magnet_forearm_z classe
## 1      -17      654      476      A
## 2      -18      661      473      A
## 3      -18      658      469      A
## 4      -16      658      469      A
## 5      -17      655      473      A
## 6       -9      660      478      A

```

I have decided to omit all factor variables and the variables containing NAs, since these contain summarized information for the day before

```

# Deleting all factor variables
idx <- which(sapply(X = training[,-dim(training)[2]], FUN = is.factor))

training <- training[, -idx]

names(training)

```

```

## [1] "roll_belt"           "pitch_belt"
## [3] "yaw_belt"            "total_accel_belt"
## [5] "max_roll_belt"       "max_pictch_belt"
## [7] "min_roll_belt"       "min_pitch_belt"
## [9] "amplitude_roll_belt" "amplitude_pitch_belt"
## [11] "var_total_accel_belt" "avg_roll_belt"
## [13] "stddev_roll_belt"    "var_roll_belt"
## [15] "avg_pitch_belt"      "stddev_pitch_belt"
## [17] "var_pitch_belt"      "avg_yaw_belt"
## [19] "stddev_yaw_belt"     "var_yaw_belt"
## [21] "gyros_belt_x"        "gyros_belt_y"
## [23] "gyros_belt_z"        "accel_belt_x"
## [25] "accel_belt_y"        "accel_belt_z"
## [27] "magnet_belt_x"       "magnet_belt_y"
## [29] "magnet_belt_z"       "roll_arm"
## [31] "pitch_arm"            "yaw_arm"
## [33] "total_accel_arm"      "var_accel_arm"
## [35] "avg_roll_arm"         "stddev_roll_arm"
## [37] "var_roll_arm"          "avg_pitch_arm"
## [39] "stddev_pitch_arm"     "var_pitch_arm"
## [41] "avg_yaw_arm"          "stddev_yaw_arm"
## [43] "var_yaw_arm"           "gyros_arm_x"
## [45] "gyros_arm_y"           "gyros_arm_z"
## [47] "accel_arm_x"           "accel_arm_y"
## [49] "accel_arm_z"           "magnet_arm_x"
## [51] "magnet_arm_y"          "magnet_arm_z"
## [53] "max_roll_arm"          "max_pictch_arm"
## [55] "max_yaw_arm"           "min_roll_arm"
## [57] "min_pitch_arm"         "min_yaw_arm"
## [59] "amplitude_roll_arm"    "amplitude_pitch_arm"
## [61] "amplitude_yaw_arm"     "roll_dumbbell"
## [63] "pitch_dumbbell"        "yaw_dumbbell"
## [65] "max_roll_dumbbell"     "max_pictch_dumbbell"
## [67] "min_roll_dumbbell"     "min_pitch_dumbbell"
## [69] "amplitude_roll_dumbbell" "amplitude_pitch_dumbbell"
## [71] "total_accel_dumbbell"   "var_accel_dumbbell"
## [73] "avg_roll_dumbbell"     "stddev_roll_dumbbell"
## [75] "var_roll_dumbbell"      "avg_pitch_dumbbell"
## [77] "stddev_pitch_dumbbell"  "var_pitch_dumbbell"
## [79] "avg_yaw_dumbbell"       "stddev_yaw_dumbbell"
## [81] "var_yaw_dumbbell"        "gyros_dumbbell_x"
## [83] "gyros_dumbbell_y"        "gyros_dumbbell_z"
## [85] "accel_dumbbell_x"        "accel_dumbbell_y"
## [87] "accel_dumbbell_z"        "magnet_dumbbell_x"
## [89] "magnet_dumbbell_y"       "magnet_dumbbell_z"
## [91] "roll_forearm"           "pitch_forearm"
## [93] "yaw_forearm"             "max_roll_forearm"
## [95] "max_pictch_forearm"      "min_roll_forearm"
## [97] "min_pitch_forearm"       "amplitude_roll_forearm"
## [99] "amplitude_pitch_forearm" "total_accel_forearm"
## [101] "var_accel_forearm"       "avg_roll_forearm"
## [103] "stddev_roll_forearm"     "var_roll_forearm"
## [105] "avg_pitch_forearm"       "stddev_pitch_forearm"
## [107] "var_pitch_forearm"       "avg_yaw_forearm"
## [109] "stddev_yaw_forearm"     "var_yaw_forearm"
## [111] "gyros_forearm_x"         "gyros_forearm_y"
## [113] "gyros_forearm_z"         "accel_forearm_x"

```

```
## [115] "accel_forearm_y"      "accel_forearm_z"
## [117] "magnet_forearm_x"       "magnet_forearm_y"
## [119] "magnet_forearm_z"       "classe"
```

```
#Now I will delete all variable, which have more than 50% NA's. These are aggregated values, as for example "avg_pitch_arm"
idy <- colSums(is.na(training[,-dim(training)[2]]))/dim(training)[1]

training <- training[,-which(idy>0.5)]
dim(training)
```

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

we have 53 columns left

2.2 Missing Values

Let us check, whether we have missing values in our data

```
any(is.na(training))
```

```
## [1] FALSE
```

```
any(is.na(training$classe))
```

```
## [1] FALSE
```

It seems that after the data cleaning, there are no more missing values in the data set.

2.3 Data Partitioning

I will split the data set into training/testing partitions.

```
inTrain <- createDataPartition(training$classe, p=0.85, list=F)
testing <- training[-inTrain,]
training <- training[inTrain,]

dim(training)
```

```
## [1] 16680    53
```

```
dim(testing)
```

```
## [1] 2942    53
```

2.4. Centering, Scaling

In order to bring all variables to the same magnitude, I will also use centering and scaling using the PreProcess function

```
prePr1 <- preProcess(training, method = c("center", "scale"))
training <- predict(prePr1, newdata=training)
testing <- predict(prePr1, newdata=testing)
```

Proving the first predictor, whether centering and scaling was successfull

```
mean(training[,1])
```

```
## [1] 8.183488e-17
```

```
sd(training[,1])
```

```
## [1] 1
```

2.4. Near Zero Values

We are going to check now whether there are Near Zero Covariates

```
nsv <- nearZeroVar(training, saveMetrics = T)
any(nsv$zeroVar==T)
```

```
## [1] FALSE
```

There are no Near Value Covariates

3. Cross Validation

As it was asked in the assignment description I will now set up a cross validation process using the train control option in the caret package

```
train_control <- trainControl(method="cv", number=10, savePredictions = TRUE)
```

4. Predicting with a random forest

I will fit first a random forest

```
modFitTree<- train(classe~, data=training, trControl=train_control, method="rf")
```

```
## Warning: package 'randomForest' was built under R version 3.4.2
```

```
## randomForest 4.6-12
```

```
## Type rfNews() to see new features/changes/bug fixes.
```

```
##
## Attaching package: 'randomForest'
```

```
## The following object is masked from 'package:dplyr':
##
##     combine
```

```
## The following object is masked from 'package:ggplot2':
##
##     margin
```

```
predTrain <- predict(modFitTree,newdata=training)
predTest <- predict(modFitTree,newdata=testing)
```

Calculating the training/testing accuracy

```
#Training accuracy
sum(predTrain == training$classe)/length(training$classe)
```

```
## [1] 1
```

```
#Testing accuracy
sum(predTest == testing$classe)/length(testing$classe)
```

```
## [1] 0.9959211
```

As it seems we could achieve very good accuracy on the testing set as well.

5. Predicting with boosting

I will try another model with boosting

```
modFitBoost<- train(classe~.,data=training,trControl=train_control,method="gbm")
```

```
## Warning: package 'gbm' was built under R version 3.4.2
```

```
## Loading required package: survival
```

```
##
## Attaching package: 'survival'
```

```
## The following object is masked from 'package:caret':
##
##     cluster
```

```
## Loading required package: splines
```

```
## Loading required package: parallel
```

```
## Loaded gbm 2.1.3
```

```
## -----
```

```
## You have loaded plyr after dplyr - this is likely to cause problems.  
## If you need functions from both plyr and dplyr, please load plyr first, then dplyr:  
## library(plyr); library(dplyr)
```

```
## -----
```

```
##  
## Attaching package: 'plyr'
```

```
## The following objects are masked from 'package:dplyr':  
##  
##     arrange, count, desc, failwith, id, mutate, rename, summarise,  
##     summarise
```

```

## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094        nan  0.1000  0.1274
##   2    1.5235        nan  0.1000  0.0872
##   3    1.4659        nan  0.1000  0.0676
##   4    1.4217        nan  0.1000  0.0535
##   5    1.3866        nan  0.1000  0.0436
##   6    1.3575        nan  0.1000  0.0464
##   7    1.3281        nan  0.1000  0.0399
##   8    1.3029        nan  0.1000  0.0338
##   9    1.2815        nan  0.1000  0.0360
##  10    1.2583        nan  0.1000  0.0312
##  20    1.1076        nan  0.1000  0.0191
##  40    0.9365        nan  0.1000  0.0080
##  60    0.8309        nan  0.1000  0.0057
##  80    0.7518        nan  0.1000  0.0056
## 100    0.6868        nan  0.1000  0.0031
## 120    0.6369        nan  0.1000  0.0029
## 140    0.5915        nan  0.1000  0.0016
## 150    0.5725        nan  0.1000  0.0025
##
## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094        nan  0.1000  0.1822
##   2    1.4889        nan  0.1000  0.1289
##   3    1.4062        nan  0.1000  0.1056
##   4    1.3382        nan  0.1000  0.0818
##   5    1.2857        nan  0.1000  0.0739
##   6    1.2383        nan  0.1000  0.0651
##   7    1.1980        nan  0.1000  0.0611
##   8    1.1591        nan  0.1000  0.0457
##   9    1.1304        nan  0.1000  0.0487
##  10    1.0992        nan  0.1000  0.0431
##  20    0.8979        nan  0.1000  0.0215
##  40    0.6887        nan  0.1000  0.0120
##  60    0.5602        nan  0.1000  0.0107
##  80    0.4740        nan  0.1000  0.0070
## 100    0.4041        nan  0.1000  0.0055
## 120    0.3485        nan  0.1000  0.0032
## 140    0.3077        nan  0.1000  0.0010
## 150    0.2909        nan  0.1000  0.0017
##
## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094        nan  0.1000  0.2323
##   2    1.4613        nan  0.1000  0.1639
##   3    1.3588        nan  0.1000  0.1316
##   4    1.2766        nan  0.1000  0.1049
##   5    1.2106        nan  0.1000  0.0847
##   6    1.1564        nan  0.1000  0.0686
##   7    1.1131        nan  0.1000  0.0779
##   8    1.0647        nan  0.1000  0.0691
##   9    1.0209        nan  0.1000  0.0513
##  10    0.9884        nan  0.1000  0.0480
##  20    0.7620        nan  0.1000  0.0316
##  40    0.5293        nan  0.1000  0.0115
##  60    0.4054        nan  0.1000  0.0074
##  80    0.3251        nan  0.1000  0.0044
## 100    0.2703        nan  0.1000  0.0042
## 120    0.2256        nan  0.1000  0.0024

```

```

##   140      0.1934      nan    0.1000    0.0018
##   150      0.1788      nan    0.1000    0.0019
##
## Iter  TrainDeviance  ValidDeviance StepSize Improve
##   1      1.6094      nan    0.1000    0.1283
##   2      1.5242      nan    0.1000    0.0871
##   3      1.4659      nan    0.1000    0.0655
##   4      1.4227      nan    0.1000    0.0582
##   5      1.3854      nan    0.1000    0.0511
##   6      1.3526      nan    0.1000    0.0394
##   7      1.3265      nan    0.1000    0.0404
##   8      1.3017      nan    0.1000    0.0316
##   9      1.2800      nan    0.1000    0.0305
##  10     1.2604      nan    0.1000    0.0321
##  20     1.1041      nan    0.1000    0.0169
##  40     0.9326      nan    0.1000    0.0084
##  60     0.8281      nan    0.1000    0.0072
##  80     0.7486      nan    0.1000    0.0058
## 100    0.6839      nan    0.1000    0.0037
## 120    0.6334      nan    0.1000    0.0028
## 140    0.5904      nan    0.1000    0.0024
## 150    0.5719      nan    0.1000    0.0024
##
## Iter  TrainDeviance  ValidDeviance StepSize Improve
##   1      1.6094      nan    0.1000    0.1893
##   2      1.4885      nan    0.1000    0.1266
##   3      1.4059      nan    0.1000    0.1084
##   4      1.3371      nan    0.1000    0.0844
##   5      1.2843      nan    0.1000    0.0714
##   6      1.2379      nan    0.1000    0.0640
##   7      1.1976      nan    0.1000    0.0664
##   8      1.1563      nan    0.1000    0.0494
##   9      1.1258      nan    0.1000    0.0469
##  10     1.0958      nan    0.1000    0.0390
##  20     0.9022      nan    0.1000    0.0202
##  40     0.6842      nan    0.1000    0.0102
##  60     0.5618      nan    0.1000    0.0077
##  80     0.4728      nan    0.1000    0.0059
## 100    0.4075      nan    0.1000    0.0031
## 120    0.3556      nan    0.1000    0.0033
## 140    0.3100      nan    0.1000    0.0015
## 150    0.2922      nan    0.1000    0.0025
##
## Iter  TrainDeviance  ValidDeviance StepSize Improve
##   1      1.6094      nan    0.1000    0.2240
##   2      1.4631      nan    0.1000    0.1641
##   3      1.3601      nan    0.1000    0.1273
##   4      1.2800      nan    0.1000    0.1102
##   5      1.2109      nan    0.1000    0.0821
##   6      1.1580      nan    0.1000    0.0845
##   7      1.1052      nan    0.1000    0.0688
##   8      1.0613      nan    0.1000    0.0674
##   9      1.0193      nan    0.1000    0.0583
##  10     0.9822      nan    0.1000    0.0449
##  20     0.7577      nan    0.1000    0.0251
##  40     0.5340      nan    0.1000    0.0110
##  60     0.4122      nan    0.1000    0.0088
##  80     0.3279      nan    0.1000    0.0051

```

```

## 100 0.2694 nan 0.1000 0.0037
## 120 0.2288 nan 0.1000 0.0024
## 140 0.1939 nan 0.1000 0.0017
## 150 0.1794 nan 0.1000 0.0012
##
## Iter TrainDeviance ValidDeviance StepSize Improve
## 1 1.6094 nan 0.1000 0.1293
## 2 1.5220 nan 0.1000 0.0879
## 3 1.4636 nan 0.1000 0.0684
## 4 1.4187 nan 0.1000 0.0529
## 5 1.3835 nan 0.1000 0.0440
## 6 1.3542 nan 0.1000 0.0449
## 7 1.3250 nan 0.1000 0.0375
## 8 1.3004 nan 0.1000 0.0358
## 9 1.2781 nan 0.1000 0.0314
## 10 1.2573 nan 0.1000 0.0267
## 20 1.1045 nan 0.1000 0.0165
## 40 0.9355 nan 0.1000 0.0093
## 60 0.8295 nan 0.1000 0.0057
## 80 0.7507 nan 0.1000 0.0069
## 100 0.6872 nan 0.1000 0.0039
## 120 0.6355 nan 0.1000 0.0029
## 140 0.5910 nan 0.1000 0.0027
## 150 0.5733 nan 0.1000 0.0022
##
## Iter TrainDeviance ValidDeviance StepSize Improve
## 1 1.6094 nan 0.1000 0.1855
## 2 1.4881 nan 0.1000 0.1328
## 3 1.4038 nan 0.1000 0.1032
## 4 1.3376 nan 0.1000 0.0835
## 5 1.2830 nan 0.1000 0.0774
## 6 1.2342 nan 0.1000 0.0606
## 7 1.1950 nan 0.1000 0.0613
## 8 1.1565 nan 0.1000 0.0547
## 9 1.1224 nan 0.1000 0.0463
## 10 1.0930 nan 0.1000 0.0364
## 20 0.8980 nan 0.1000 0.0217
## 40 0.6839 nan 0.1000 0.0124
## 60 0.5545 nan 0.1000 0.0069
## 80 0.4715 nan 0.1000 0.0052
## 100 0.4060 nan 0.1000 0.0034
## 120 0.3494 nan 0.1000 0.0028
## 140 0.3079 nan 0.1000 0.0017
## 150 0.2897 nan 0.1000 0.0018
##
## Iter TrainDeviance ValidDeviance StepSize Improve
## 1 1.6094 nan 0.1000 0.2339
## 2 1.4613 nan 0.1000 0.1608
## 3 1.3592 nan 0.1000 0.1242
## 4 1.2801 nan 0.1000 0.1052
## 5 1.2143 nan 0.1000 0.0883
## 6 1.1576 nan 0.1000 0.0778
## 7 1.1097 nan 0.1000 0.0656
## 8 1.0684 nan 0.1000 0.0699
## 9 1.0263 nan 0.1000 0.0609
## 10 0.9886 nan 0.1000 0.0526
## 20 0.7543 nan 0.1000 0.0250
## 40 0.5306 nan 0.1000 0.0124

```

```

##      60      0.4085      nan    0.1000    0.0085
##      80      0.3259      nan    0.1000    0.0037
##     100      0.2680      nan    0.1000    0.0028
##     120      0.2225      nan    0.1000    0.0022
##     140      0.1895      nan    0.1000    0.0023
##     150      0.1764      nan    0.1000    0.0018
##
## Iter   TrainDeviance  ValidDeviance StepSize Improve
##      1      1.6094      nan    0.1000    0.1300
##      2      1.5230      nan    0.1000    0.0872
##      3      1.4639      nan    0.1000    0.0656
##      4      1.4200      nan    0.1000    0.0542
##      5      1.3840      nan    0.1000    0.0450
##      6      1.3544      nan    0.1000    0.0447
##      7      1.3257      nan    0.1000    0.0362
##      8      1.3017      nan    0.1000    0.0350
##      9      1.2794      nan    0.1000    0.0344
##     10      1.2587      nan    0.1000    0.0303
##     20      1.1055      nan    0.1000    0.0160
##     40      0.9337      nan    0.1000    0.0080
##     60      0.8283      nan    0.1000    0.0057
##     80      0.7488      nan    0.1000    0.0045
##    100      0.6874      nan    0.1000    0.0027
##    120      0.6349      nan    0.1000    0.0029
##    140      0.5910      nan    0.1000    0.0027
##    150      0.5728      nan    0.1000    0.0020
##
## Iter   TrainDeviance  ValidDeviance StepSize Improve
##      1      1.6094      nan    0.1000    0.1822
##      2      1.4885      nan    0.1000    0.1321
##      3      1.4046      nan    0.1000    0.1054
##      4      1.3390      nan    0.1000    0.0814
##      5      1.2866      nan    0.1000    0.0706
##      6      1.2406      nan    0.1000    0.0723
##      7      1.1960      nan    0.1000    0.0600
##      8      1.1581      nan    0.1000    0.0522
##      9      1.1250      nan    0.1000    0.0459
##     10      1.0958      nan    0.1000    0.0391
##     20      0.8984      nan    0.1000    0.0267
##     40      0.6811      nan    0.1000    0.0095
##     60      0.5614      nan    0.1000    0.0097
##     80      0.4727      nan    0.1000    0.0032
##    100      0.4086      nan    0.1000    0.0040
##    120      0.3538      nan    0.1000    0.0035
##    140      0.3121      nan    0.1000    0.0040
##    150      0.2942      nan    0.1000    0.0013
##
## Iter   TrainDeviance  ValidDeviance StepSize Improve
##      1      1.6094      nan    0.1000    0.2325
##      2      1.4601      nan    0.1000    0.1583
##      3      1.3581      nan    0.1000    0.1278
##      4      1.2760      nan    0.1000    0.1067
##      5      1.2095      nan    0.1000    0.0804
##      6      1.1582      nan    0.1000    0.0756
##      7      1.1091      nan    0.1000    0.0686
##      8      1.0653      nan    0.1000    0.0694
##      9      1.0221      nan    0.1000    0.0597
##     10      0.9849      nan    0.1000    0.0550

```

```

##    20    0.7576      nan  0.1000  0.0212
##    40    0.5346      nan  0.1000  0.0110
##    60    0.4116      nan  0.1000  0.0076
##    80    0.3292      nan  0.1000  0.0036
##   100    0.2689      nan  0.1000  0.0028
##   120    0.2251      nan  0.1000  0.0024
##   140    0.1920      nan  0.1000  0.0022
##   150    0.1766      nan  0.1000  0.0012
##
## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094      nan  0.1000  0.1295
##   2    1.5237      nan  0.1000  0.0861
##   3    1.4663      nan  0.1000  0.0673
##   4    1.4218      nan  0.1000  0.0559
##   5    1.3859      nan  0.1000  0.0444
##   6    1.3564      nan  0.1000  0.0461
##   7    1.3278      nan  0.1000  0.0382
##   8    1.3036      nan  0.1000  0.0343
##   9    1.2827      nan  0.1000  0.0294
##  10    1.2635      nan  0.1000  0.0297
##  20    1.1076      nan  0.1000  0.0193
##  40    0.9359      nan  0.1000  0.0099
##  60    0.8296      nan  0.1000  0.0063
##  80    0.7499      nan  0.1000  0.0048
## 100    0.6885      nan  0.1000  0.0046
## 120    0.6355      nan  0.1000  0.0030
## 140    0.5930      nan  0.1000  0.0023
## 150    0.5734      nan  0.1000  0.0029
##
## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094      nan  0.1000  0.1905
##   2    1.4879      nan  0.1000  0.1311
##   3    1.4041      nan  0.1000  0.1002
##   4    1.3396      nan  0.1000  0.0848
##   5    1.2846      nan  0.1000  0.0702
##   6    1.2389      nan  0.1000  0.0597
##   7    1.2006      nan  0.1000  0.0617
##   8    1.1614      nan  0.1000  0.0451
##   9    1.1319      nan  0.1000  0.0501
##  10    1.1018      nan  0.1000  0.0436
##  20    0.8990      nan  0.1000  0.0225
##  40    0.6863      nan  0.1000  0.0084
##  60    0.5620      nan  0.1000  0.0069
##  80    0.4715      nan  0.1000  0.0054
## 100    0.4068      nan  0.1000  0.0035
## 120    0.3553      nan  0.1000  0.0046
## 140    0.3141      nan  0.1000  0.0031
## 150    0.2962      nan  0.1000  0.0020
##
## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094      nan  0.1000  0.2309
##   2    1.4622      nan  0.1000  0.1591
##   3    1.3612      nan  0.1000  0.1268
##   4    1.2814      nan  0.1000  0.1060
##   5    1.2153      nan  0.1000  0.0902
##   6    1.1590      nan  0.1000  0.0814
##   7    1.1076      nan  0.1000  0.0596
##   8    1.0693      nan  0.1000  0.0604

```

```

##      9    1.0313      nan  0.1000  0.0606
##     10    0.9922      nan  0.1000  0.0457
##     20    0.7610      nan  0.1000  0.0247
##     40    0.5354      nan  0.1000  0.0117
##     60    0.4083      nan  0.1000  0.0077
##     80    0.3254      nan  0.1000  0.0042
##    100    0.2689      nan  0.1000  0.0032
##    120    0.2269      nan  0.1000  0.0021
##    140    0.1943      nan  0.1000  0.0016
##    150    0.1798      nan  0.1000  0.0013
##
## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094      nan  0.1000  0.1293
##   2    1.5236      nan  0.1000  0.0895
##   3    1.4647      nan  0.1000  0.0669
##   4    1.4211      nan  0.1000  0.0554
##   5    1.3843      nan  0.1000  0.0425
##   6    1.3557      nan  0.1000  0.0464
##   7    1.3265      nan  0.1000  0.0383
##   8    1.3021      nan  0.1000  0.0357
##   9    1.2798      nan  0.1000  0.0309
##  10    1.2602      nan  0.1000  0.0312
##  20    1.1062      nan  0.1000  0.0161
##  40    0.9354      nan  0.1000  0.0092
##  60    0.8302      nan  0.1000  0.0053
##  80    0.7527      nan  0.1000  0.0055
## 100    0.6891      nan  0.1000  0.0035
## 120    0.6387      nan  0.1000  0.0026
## 140    0.5932      nan  0.1000  0.0024
## 150    0.5737      nan  0.1000  0.0022
##
## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094      nan  0.1000  0.1840
##   2    1.4903      nan  0.1000  0.1350
##   3    1.4050      nan  0.1000  0.1020
##   4    1.3404      nan  0.1000  0.0871
##   5    1.2853      nan  0.1000  0.0698
##   6    1.2406      nan  0.1000  0.0603
##   7    1.2019      nan  0.1000  0.0655
##   8    1.1624      nan  0.1000  0.0562
##   9    1.1267      nan  0.1000  0.0396
##  10    1.1007      nan  0.1000  0.0417
##  20    0.8997      nan  0.1000  0.0195
##  40    0.6885      nan  0.1000  0.0108
##  60    0.5617      nan  0.1000  0.0051
##  80    0.4733      nan  0.1000  0.0048
## 100    0.4093      nan  0.1000  0.0035
## 120    0.3566      nan  0.1000  0.0019
## 140    0.3164      nan  0.1000  0.0016
## 150    0.2957      nan  0.1000  0.0021
##
## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094      nan  0.1000  0.2369
##   2    1.4609      nan  0.1000  0.1611
##   3    1.3595      nan  0.1000  0.1289
##   4    1.2774      nan  0.1000  0.1000
##   5    1.2135      nan  0.1000  0.0820
##   6    1.1599      nan  0.1000  0.0803

```

```

##      7    1.1098      nan  0.1000  0.0653
##      8    1.0693      nan  0.1000  0.0604
##      9    1.0316      nan  0.1000  0.0502
##     10    0.9984      nan  0.1000  0.0581
##    20    0.7660      nan  0.1000  0.0324
##   40    0.5337      nan  0.1000  0.0111
##   60    0.4082      nan  0.1000  0.0081
##   80    0.3250      nan  0.1000  0.0041
## 100    0.2654      nan  0.1000  0.0032
## 120    0.2235      nan  0.1000  0.0021
## 140    0.1899      nan  0.1000  0.0032
## 150    0.1762      nan  0.1000  0.0012
##
## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094      nan  0.1000  0.1303
##   2    1.5231      nan  0.1000  0.0852
##   3    1.4650      nan  0.1000  0.0688
##   4    1.4200      nan  0.1000  0.0534
##   5    1.3843      nan  0.1000  0.0419
##   6    1.3558      nan  0.1000  0.0453
##   7    1.3272      nan  0.1000  0.0368
##   8    1.3032      nan  0.1000  0.0358
##   9    1.2807      nan  0.1000  0.0310
##  10    1.2612      nan  0.1000  0.0279
##  20    1.1074      nan  0.1000  0.0160
##  40    0.9369      nan  0.1000  0.0103
##  60    0.8309      nan  0.1000  0.0065
##  80    0.7518      nan  0.1000  0.0059
## 100    0.6899      nan  0.1000  0.0052
## 120    0.6387      nan  0.1000  0.0022
## 140    0.5945      nan  0.1000  0.0018
## 150    0.5754      nan  0.1000  0.0015
##
## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094      nan  0.1000  0.1820
##   2    1.4895      nan  0.1000  0.1304
##   3    1.4059      nan  0.1000  0.1005
##   4    1.3410      nan  0.1000  0.0819
##   5    1.2882      nan  0.1000  0.0776
##   6    1.2399      nan  0.1000  0.0656
##   7    1.1987      nan  0.1000  0.0632
##   8    1.1586      nan  0.1000  0.0439
##   9    1.1300      nan  0.1000  0.0408
##  10    1.1030      nan  0.1000  0.0492
##  20    0.9011      nan  0.1000  0.0221
##  40    0.6877      nan  0.1000  0.0105
##  60    0.5628      nan  0.1000  0.0070
##  80    0.4747      nan  0.1000  0.0044
## 100    0.4116      nan  0.1000  0.0036
## 120    0.3579      nan  0.1000  0.0023
## 140    0.3168      nan  0.1000  0.0031
## 150    0.2977      nan  0.1000  0.0021
##
## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094      nan  0.1000  0.2357
##   2    1.4597      nan  0.1000  0.1575
##   3    1.3601      nan  0.1000  0.1198
##   4    1.2832      nan  0.1000  0.1079

```

```

##      5    1.2161      nan  0.1000  0.0884
##      6    1.1607      nan  0.1000  0.0831
##      7    1.1088      nan  0.1000  0.0661
##      8    1.0660      nan  0.1000  0.0697
##      9    1.0230      nan  0.1000  0.0599
##     10    0.9860      nan  0.1000  0.0472
##    20    0.7618      nan  0.1000  0.0245
##    40    0.5386      nan  0.1000  0.0133
##   60    0.4129      nan  0.1000  0.0059
##  80    0.3270      nan  0.1000  0.0047
## 100   0.2687      nan  0.1000  0.0026
## 120   0.2252      nan  0.1000  0.0026
## 140   0.1912      nan  0.1000  0.0012
## 150   0.1767      nan  0.1000  0.0014
##
## Iter  TrainDeviance  ValidDeviance StepSize Improve
##   1    1.6094        nan  0.1000  0.1271
##   2    1.5245        nan  0.1000  0.0882
##   3    1.4662        nan  0.1000  0.0658
##   4    1.4228        nan  0.1000  0.0552
##   5    1.3865        nan  0.1000  0.0510
##   6    1.3540        nan  0.1000  0.0394
##   7    1.3290        nan  0.1000  0.0411
##   8    1.3037        nan  0.1000  0.0353
##   9    1.2819        nan  0.1000  0.0278
##  10   1.2639        nan  0.1000  0.0305
##  20   1.1092        nan  0.1000  0.0181
##  40   0.9370        nan  0.1000  0.0072
##  60   0.8316        nan  0.1000  0.0048
##  80   0.7536        nan  0.1000  0.0037
## 100   0.6905        nan  0.1000  0.0038
## 120   0.6384        nan  0.1000  0.0040
## 140   0.5936        nan  0.1000  0.0034
## 150   0.5736        nan  0.1000  0.0020
##
## Iter  TrainDeviance  ValidDeviance StepSize Improve
##   1    1.6094        nan  0.1000  0.1807
##   2    1.4911        nan  0.1000  0.1309
##   3    1.4076        nan  0.1000  0.1070
##   4    1.3395        nan  0.1000  0.0860
##   5    1.2851        nan  0.1000  0.0699
##   6    1.2403        nan  0.1000  0.0600
##   7    1.2023        nan  0.1000  0.0625
##   8    1.1630        nan  0.1000  0.0578
##   9    1.1266        nan  0.1000  0.0449
##  10   1.0986        nan  0.1000  0.0396
##  20   0.9025        nan  0.1000  0.0213
##  40   0.6878        nan  0.1000  0.0094
##  60   0.5605        nan  0.1000  0.0100
##  80   0.4702        nan  0.1000  0.0053
## 100   0.4039        nan  0.1000  0.0034
## 120   0.3525        nan  0.1000  0.0020
## 140   0.3094        nan  0.1000  0.0035
## 150   0.2909        nan  0.1000  0.0026
##
## Iter  TrainDeviance  ValidDeviance StepSize Improve
##   1    1.6094        nan  0.1000  0.2266
##   2    1.4647        nan  0.1000  0.1629

```

```

##      3    1.3615      nan  0.1000  0.1271
##      4    1.2824      nan  0.1000  0.1071
##      5    1.2127      nan  0.1000  0.0879
##      6    1.1578      nan  0.1000  0.0739
##      7    1.1105      nan  0.1000  0.0645
##      8    1.0691      nan  0.1000  0.0662
##      9    1.0272      nan  0.1000  0.0597
##     10    0.9902      nan  0.1000  0.0511
##    20    0.7621      nan  0.1000  0.0249
##   40    0.5326      nan  0.1000  0.0106
##   60    0.4097      nan  0.1000  0.0078
##   80    0.3285      nan  0.1000  0.0057
## 100    0.2706      nan  0.1000  0.0037
## 120    0.2285      nan  0.1000  0.0026
## 140    0.1947      nan  0.1000  0.0018
## 150    0.1800      nan  0.1000  0.0011
##
## Iter  TrainDeviance  ValidDeviance StepSize Improve
##   1    1.6094      nan  0.1000  0.1258
##   2    1.5241      nan  0.1000  0.0864
##   3    1.4665      nan  0.1000  0.0644
##   4    1.4241      nan  0.1000  0.0562
##   5    1.3876      nan  0.1000  0.0437
##   6    1.3581      nan  0.1000  0.0436
##   7    1.3294      nan  0.1000  0.0367
##   8    1.3058      nan  0.1000  0.0361
##   9    1.2831      nan  0.1000  0.0331
##  10    1.2618      nan  0.1000  0.0302
##  20    1.1115      nan  0.1000  0.0189
##  40    0.9422      nan  0.1000  0.0077
##  60    0.8356      nan  0.1000  0.0061
##  80    0.7548      nan  0.1000  0.0030
## 100    0.6933      nan  0.1000  0.0040
## 120    0.6415      nan  0.1000  0.0027
## 140    0.5968      nan  0.1000  0.0027
## 150    0.5772      nan  0.1000  0.0022
##
## Iter  TrainDeviance  ValidDeviance StepSize Improve
##   1    1.6094      nan  0.1000  0.1841
##   2    1.4910      nan  0.1000  0.1299
##   3    1.4079      nan  0.1000  0.1040
##   4    1.3422      nan  0.1000  0.0792
##   5    1.2916      nan  0.1000  0.0684
##   6    1.2481      nan  0.1000  0.0710
##   7    1.2043      nan  0.1000  0.0639
##   8    1.1638      nan  0.1000  0.0566
##   9    1.1297      nan  0.1000  0.0438
##  10    1.1020      nan  0.1000  0.0425
##  20    0.8982      nan  0.1000  0.0196
##  40    0.6867      nan  0.1000  0.0090
##  60    0.5625      nan  0.1000  0.0065
##  80    0.4766      nan  0.1000  0.0044
## 100    0.4072      nan  0.1000  0.0050
## 120    0.3541      nan  0.1000  0.0033
## 140    0.3121      nan  0.1000  0.0018
## 150    0.2954      nan  0.1000  0.0027
##
## Iter  TrainDeviance  ValidDeviance StepSize Improve

```

```

##      1    1.6094      nan   0.1000   0.2337
##      2    1.4608      nan   0.1000   0.1591
##      3    1.3599      nan   0.1000   0.1190
##      4    1.2850      nan   0.1000   0.1047
##      5    1.2202      nan   0.1000   0.0937
##      6    1.1608      nan   0.1000   0.0807
##      7    1.1100      nan   0.1000   0.0661
##      8    1.0677      nan   0.1000   0.0605
##      9    1.0289      nan   0.1000   0.0556
##     10    0.9931      nan   0.1000   0.0569
##    20    0.7591      nan   0.1000   0.0224
##    40    0.5289      nan   0.1000   0.0111
##    60    0.4095      nan   0.1000   0.0092
##    80    0.3271      nan   0.1000   0.0067
##   100    0.2709      nan   0.1000   0.0039
##   120    0.2287      nan   0.1000   0.0016
##   140    0.1944      nan   0.1000   0.0015
##   150    0.1793      nan   0.1000   0.0016
##
## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094      nan   0.1000   0.1271
##   2    1.5230      nan   0.1000   0.0873
##   3    1.4641      nan   0.1000   0.0650
##   4    1.4206      nan   0.1000   0.0576
##   5    1.3841      nan   0.1000   0.0450
##   6    1.3549      nan   0.1000   0.0440
##   7    1.3270      nan   0.1000   0.0403
##   8    1.3024      nan   0.1000   0.0348
##   9    1.2799      nan   0.1000   0.0327
##  10    1.2593      nan   0.1000   0.0314
##  20    1.1077      nan   0.1000   0.0194
##  40    0.9350      nan   0.1000   0.0097
##  60    0.8306      nan   0.1000   0.0055
##  80    0.7501      nan   0.1000   0.0044
## 100    0.6890      nan   0.1000   0.0046
## 120    0.6373      nan   0.1000   0.0031
## 140    0.5926      nan   0.1000   0.0025
## 150    0.5738      nan   0.1000   0.0036
##
## Iter TrainDeviance ValidDeviance StepSize Improve
##   1    1.6094      nan   0.1000   0.1810
##   2    1.4911      nan   0.1000   0.1308
##   3    1.4078      nan   0.1000   0.1038
##   4    1.3415      nan   0.1000   0.0813
##   5    1.2894      nan   0.1000   0.0697
##   6    1.2445      nan   0.1000   0.0671
##   7    1.2014      nan   0.1000   0.0582
##   8    1.1653      nan   0.1000   0.0575
##   9    1.1296      nan   0.1000   0.0470
##  10    1.1004      nan   0.1000   0.0426
##  20    0.9022      nan   0.1000   0.0238
##  40    0.6876      nan   0.1000   0.0121
##  60    0.5612      nan   0.1000   0.0079
##  80    0.4695      nan   0.1000   0.0040
## 100    0.4037      nan   0.1000   0.0036
## 120    0.3542      nan   0.1000   0.0028
## 140    0.3132      nan   0.1000   0.0035
## 150    0.2953      nan   0.1000   0.0021

```

```

## 
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##    1      1.6094          nan     0.1000  0.2354
##    2      1.4614          nan     0.1000  0.1591
##    3      1.3600          nan     0.1000  0.1341
##    4      1.2764          nan     0.1000  0.1052
##    5      1.2102          nan     0.1000  0.0839
##    6      1.1569          nan     0.1000  0.0738
##    7      1.1109          nan     0.1000  0.0754
##    8      1.0649          nan     0.1000  0.0627
##    9      1.0261          nan     0.1000  0.0600
##   10      0.9888          nan     0.1000  0.0532
##   20      0.7548          nan     0.1000  0.0233
##   40      0.5369          nan     0.1000  0.0130
##   60      0.4129          nan     0.1000  0.0088
##   80      0.3281          nan     0.1000  0.0060
##  100      0.2671          nan     0.1000  0.0029
##  120      0.2251          nan     0.1000  0.0029
##  140      0.1903          nan     0.1000  0.0014
##  150      0.1774          nan     0.1000  0.0024
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##    1      1.6094          nan     0.1000  0.2292
##    2      1.4605          nan     0.1000  0.1604
##    3      1.3598          nan     0.1000  0.1255
##    4      1.2800          nan     0.1000  0.1006
##    5      1.2159          nan     0.1000  0.0879
##    6      1.1612          nan     0.1000  0.0761
##    7      1.1124          nan     0.1000  0.0681
##    8      1.0695          nan     0.1000  0.0602
##    9      1.0319          nan     0.1000  0.0607
##   10      0.9941          nan     0.1000  0.0576
##   20      0.7672          nan     0.1000  0.0210
##   40      0.5346          nan     0.1000  0.0136
##   60      0.4101          nan     0.1000  0.0076
##   80      0.3292          nan     0.1000  0.0049
##  100      0.2707          nan     0.1000  0.0035
##  120      0.2268          nan     0.1000  0.0030
##  140      0.1934          nan     0.1000  0.0021
##  150      0.1798          nan     0.1000  0.0014

```

```

predTrain1 <- predict(modFitBoost,newdata=training)
predTest1 <- predict(modFitBoost,newdata=testing)

```

```

#Training accuracy
sum(predTrain1 == training$classe)/length(training$classe)

```

```

## [1] 0.9730815

```

```

#Testing accuracy
sum(predTest1 == testing$classe)/length(testing$classe)

```

```

## [1] 0.9622706

```

We can see that the random forest has better prediction accuracy.