PML01

GgYy

20160710

1.Install needed packages

```
#install.packages("data.table")
#install.packages("caret")
#install.packages("randomForest")
#install.packages("foreach")
#install.packages("rpart")
#install.packages("rpart.plot")
#install.packages("corrplot")
```

2.Load needed packages

```
library(data.table)
```

```
## Warning: package 'data.table' was built under R version 3.2.5
```

```
library(caret)
```

```
## Warning: package 'caret' was built under R version 3.2.5
```

```
## Loading required package: lattice
```

```
## Loading required package: ggplot2
```

```
## Warning: package 'ggplot2' was built under R version 3.2.5
```

```
library(randomForest)
```

```
## Warning: package 'randomForest' was built under R version 3.2.5
```

```
## 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(foreach)
```

```
## Warning: package 'foreach' was built under R version 3.2.5
```

```
library(rpart)
```

```
## Warning: package 'rpart' was built under R version 3.2.5
```

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

```
## Warning: package 'rpart.plot' was built under R version 3.2.5
```

```
library(corrplot)
```

```
## Warning: package 'corrplot' was built under R version 3.2.5
```

3.Read datas

```
training_data <- read.csv("pml-training.csv", na.strings=c("#DIV/0!"," ", "",
"NA", "NAs", "NULL"))
testing_data <- read.csv("pml-testing.csv", na.strings=c("#DIV/0!"," ", "", "N
A", "NAs", "NULL"))
```

4.Clean datas Drop NAs, Drop highly corelated variables, drop variables whose contents are the same.

```
#4.1 Drop columns with NAs
str(training_data)
```

```
## 'data.frame':    19622 obs. of  160 variables:
##  $ X                       : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ user_name               : Factor w/ 6 levels "adelmo","carlitos",..: 2 2
2 2 2 2 2 2 2 2 ...
##  $ raw_timestamp_part_1    : int  1323084231 1323084231 1323084231 132308423
2 1323084232 1323084232 1323084232 1323084232 1323084232 1323084232 ...
##  $ raw_timestamp_part_2    : int  788290 808298 820366 120339 196328 304277
368296 440390 484323 484434 ...
##  $ cvtd_timestamp          : Factor w/ 20 levels "02/12/2011 13:32",..: 9 9
9 9 9 9 9 9 9 9 ...
##  $ new_window              : Factor w/ 2 levels "no","yes": 1 1 1 1 1 1 1 1
1 1 ...
##  $ num_window              : int  11 11 11 12 12 12 12 12 12 12 ...
##  $ roll_belt               : num  1.41 1.41 1.42 1.48 1.48 1.45 1.42 1.42 1.
43 1.45 ...
##  $ pitch_belt              : num  8.07 8.07 8.07 8.05 8.07 8.06 8.09 8.13 8.
16 8.17 ...
##  $ yaw_belt                : num  -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4
-94.4 -94.4 -94.4 ...
##  $ total_accel_belt        : int  3 3 3 3 3 3 3 3 3 3 ...
##  $ kurtosis_roll_belt      : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ kurtosis_picth_belt     : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ kurtosis_yaw_belt       : logi  NA NA NA NA NA NA ...
##  $ skewness_roll_belt      : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ skewness_roll_belt.1    : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ skewness_yaw_belt       : logi  NA NA NA NA NA NA ...
##  $ max_roll_belt           : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ max_picth_belt          : int  NA NA NA NA NA NA NA NA NA NA ...
##  $ max_yaw_belt            : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ min_roll_belt           : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ min_pitch_belt          : int  NA NA NA NA NA NA NA NA NA NA ...
##  $ min_yaw_belt            : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ amplitude_roll_belt     : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ amplitude_pitch_belt    : int  NA NA NA NA NA NA NA NA NA NA ...
##  $ amplitude_yaw_belt      : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ var_total_accel_belt    : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ avg_roll_belt           : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ stddev_roll_belt        : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ var_roll_belt           : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ avg_pitch_belt          : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ stddev_pitch_belt       : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ var_pitch_belt          : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ avg_yaw_belt            : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ stddev_yaw_belt         : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ var_yaw_belt            : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ gyros_belt_x            : num  0 0.02 0 0.02 0.02 0.02 0.02 0.02 0.02 0.0
3 ...
##  $ gyros_belt_y            : num  0 0 0 0 0.02 0 0 0 0 0 ...
```

```
##  $ gyros_belt_z            : num  -0.02 -0.02 -0.02 -0.03 -0.02 -0.02 -0.02
-0.02 -0.02 0 ...
##  $ accel_belt_x            : int  -21 -22 -20 -22 -21 -21 -22 -22 -20 -2
1 ...
##  $ accel_belt_y            : int  4 4 5 3 2 4 3 4 2 4 ...
##  $ accel_belt_z            : int  22 22 23 21 24 21 21 21 24 22 ...
##  $ magnet_belt_x           : int  -3 -7 -2 -6 -6 0 -4 -2 1 -3 ...
##  $ magnet_belt_y           : int  599 608 600 604 600 603 599 603 602 60
9 ...
##  $ magnet_belt_z           : int  -313 -311 -305 -310 -302 -312 -311 -313 -3
12 -308 ...
##  $ roll_arm                : num  -128 -128 -128 -128 -128 -128 -128 -128 -1
28 -128 ...
##  $ pitch_arm               : num  22.5 22.5 22.5 22.1 22.1 22 21.9 21.8 21.
7 21.6 ...
##  $ yaw_arm                 : num  -161 -161 -161 -161 -161 -161 -161 -161 -1
61 -161 ...
##  $ total_accel_arm         : int  34 34 34 34 34 34 34 34 34 34 ...
##  $ var_accel_arm           : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ avg_roll_arm            : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ stddev_roll_arm         : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ var_roll_arm            : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ avg_pitch_arm           : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ stddev_pitch_arm        : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ var_pitch_arm           : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ avg_yaw_arm             : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ stddev_yaw_arm          : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ var_yaw_arm             : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ gyros_arm_x             : num  0 0.02 0.02 0.02 0 0.02 0 0.02 0.02 0.0
2 ...
##  $ gyros_arm_y             : num  0 -0.02 -0.02 -0.03 -0.03 -0.03 -0.03 -0.0
2 -0.03 -0.03 ...
##  $ gyros_arm_z             : num  -0.02 -0.02 -0.02 0.02 0 0 0 0 -0.02 -0.0
2 ...
##  $ accel_arm_x             : int  -288 -290 -289 -289 -289 -289 -289 -289 -2
88 -288 ...
##  $ accel_arm_y             : int  109 110 110 111 111 111 111 111 109 11
0 ...
##  $ accel_arm_z             : int  -123 -125 -126 -123 -123 -122 -125 -124 -1
22 -124 ...
##  $ magnet_arm_x            : int  -368 -369 -368 -372 -374 -369 -373 -372 -3
69 -376 ...
##  $ magnet_arm_y            : int  337 337 344 344 337 342 336 338 341 33
4 ...
##  $ magnet_arm_z            : int  516 513 513 512 506 513 509 510 518 51
6 ...
##  $ kurtosis_roll_arm       : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ kurtosis_picth_arm      : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ kurtosis_yaw_arm        : num  NA NA NA NA NA NA NA NA NA NA ...
```

```
##  $ skewness_roll_arm       : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ skewness_pitch_arm      : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ skewness_yaw_arm        : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ max_roll_arm            : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ max_picth_arm           : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ max_yaw_arm             : int  NA NA NA NA NA NA NA NA NA NA ...
##  $ min_roll_arm            : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ min_pitch_arm           : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ min_yaw_arm             : int  NA NA NA NA NA NA NA NA NA NA ...
##  $ amplitude_roll_arm      : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ amplitude_pitch_arm     : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ amplitude_yaw_arm       : int  NA NA NA NA NA NA NA NA NA NA ...
##  $ roll_dumbbell           : num  13.1 13.1 12.9 13.4 13.4 ...
##  $ pitch_dumbbell          : num  -70.5 -70.6 -70.3 -70.4 -70.4 ...
##  $ yaw_dumbbell            : num  -84.9 -84.7 -85.1 -84.9 -84.9 ...
##  $ kurtosis_roll_dumbbell  : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ kurtosis_picth_dumbbell : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ kurtosis_yaw_dumbbell   : logi  NA NA NA NA NA NA ...
##  $ skewness_roll_dumbbell  : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ skewness_pitch_dumbbell : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ skewness_yaw_dumbbell   : logi  NA NA NA NA NA NA ...
##  $ max_roll_dumbbell       : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ max_picth_dumbbell      : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ max_yaw_dumbbell        : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ min_roll_dumbbell       : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ min_pitch_dumbbell      : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ min_yaw_dumbbell        : num  NA NA NA NA NA NA NA NA NA NA ...
##  $ amplitude_roll_dumbbell : num  NA NA NA NA NA NA NA NA NA NA ...
##   [list output truncated]
```

```
cleantraining <- training_data[, -which(names(training_data) %in% c("X", "user_
name", "raw_timestamp_part_1", "raw_timestamp_part_2", "cvtd_timestamp", "new_w
indow", "num_window"))]
cleantraining = cleantraining[, colSums(is.na(cleantraining)) == 0]
#4.2 Drop variables with same content
zerovariance =nearZeroVar(cleantraining[sapply(cleantraining, is.numeric)], sav
eMetrics=TRUE)
cleantraining = cleantraining[, zerovariance[, 'nzv'] == 0]
#4.3.1 Return the correlation matrix in matrix format
correlationmatrix <- cor(na.omit(cleantraining[sapply(cleantraining, is.numeri
c)]))
dim(correlationmatrix)
```

```
## [1] 52 52
```

```
correlationmatrixdegreesoffreedom <- expand.grid(row = 1:52, col = 1:52)
correlationmatrixdegreesoffreedom$correlation <- as.vector(correlationmatrix)
#4.3.2 Remove highly correlated variables(up to 0.7)
removehighcorrelation <- findCorrelation(correlationmatrix, cutoff = .7, verbos
e = TRUE)
```

```
## Compare row 10  and column  1 with corr  0.992
##   Means:  0.27 vs 0.168 so flagging column 10
## Compare row 1  and column  9 with corr  0.925
##   Means:  0.25 vs 0.164 so flagging column 1
## Compare row 9  and column  22 with corr  0.722
##   Means:  0.233 vs 0.161 so flagging column 9
## Compare row 22  and column  4 with corr  0.759
##   Means:  0.224 vs 0.158 so flagging column 22
## Compare row 4  and column  3 with corr  0.762
##   Means:  0.2 vs 0.155 so flagging column 4
## Compare row 3  and column  8 with corr  0.708
##   Means:  0.2 vs 0.153 so flagging column 3
## Compare row 36  and column  29 with corr  0.849
##   Means:  0.257 vs 0.151 so flagging column 36
## Compare row 8  and column  2 with corr  0.966
##   Means:  0.229 vs 0.146 so flagging column 8
## Compare row 2  and column  11 with corr  0.884
##   Means:  0.212 vs 0.143 so flagging column 2
## Compare row 37  and column  38 with corr  0.769
##   Means:  0.198 vs 0.139 so flagging column 37
## Compare row 35  and column  30 with corr  0.773
##   Means:  0.195 vs 0.137 so flagging column 35
## Compare row 38  and column  5 with corr  0.781
##   Means:  0.177 vs 0.134 so flagging column 38
## Compare row 21  and column  24 with corr  0.814
##   Means:  0.176 vs 0.133 so flagging column 21
## Compare row 34  and column  28 with corr  0.808
##   Means:  0.176 vs 0.13 so flagging column 34
## Compare row 23  and column  26 with corr  0.779
##   Means:  0.137 vs 0.129 so flagging column 23
## Compare row 25  and column  24 with corr  0.792
##   Means:  0.145 vs 0.128 so flagging column 25
## Compare row 12  and column  13 with corr  0.779
##   Means:  0.122 vs 0.127 so flagging column 13
## Compare row 48  and column  51 with corr  0.772
##   Means:  0.145 vs 0.127 so flagging column 48
## Compare row 19  and column  18 with corr  0.918
##   Means:  0.095 vs 0.127 so flagging column 18
## Compare row 46  and column  45 with corr  0.846
##   Means:  0.131 vs 0.129 so flagging column 46
## Compare row 45  and column  31 with corr  0.71
##   Means:  0.098 vs 0.129 so flagging column 31
## Compare row 45  and column  33 with corr  0.716
##   Means:  0.078 vs 0.132 so flagging column 33
## All correlations <= 0.7
```

```
cleantraining <- cleantraining[, -removehighcorrelation]
#4.4 Generally drop blanks
for(i in c(8:ncol(cleantraining)-1)) {cleantraining[,i] = as.numeric(as.charact
er(cleantraining[,i]))}

for(i in c(8:ncol(testing_data)-1)) {testing_data[,i] = as.numeric(as.character
(testing_data[,i]))}
#4.5 Redefine to be used data
featureset <- colnames(cleantraining[colSums(is.na(cleantraining)) == 0])[-(1:
7)]
modeldata <- cleantraining[featureset]
featureset
```

```
##  [1] "yaw_arm"              "total_accel_arm"      "gyros_arm_y"
##  [4] "gyros_arm_z"          "magnet_arm_x"         "magnet_arm_z"
##  [7] "roll_dumbbell"        "pitch_dumbbell"       "yaw_dumbbell"
## [10] "total_accel_dumbbell" "gyros_dumbbell_y"     "magnet_dumbbell_z"
## [13] "roll_forearm"         "pitch_forearm"        "yaw_forearm"
## [16] "total_accel_forearm"  "gyros_forearm_x"      "gyros_forearm_y"
## [19] "accel_forearm_x"      "accel_forearm_z"      "magnet_forearm_x"
## [22] "magnet_forearm_y"     "magnet_forearm_z"     "classe"
```

5.Build model Split 60% for training and 40% for testing.

```
idx <- createDataPartition(modeldata$classe, p=0.6, list=FALSE )
training <- modeldata[idx,]
testing <- modeldata[-idx,]
```

5 fold cross validation is used.

```
control <- trainControl(method="cv", 5)
modelRF<- train(classe ~ ., data=training, method="rf", trControl=control)
modelLDA<-train(classe ~ ., data=training, method="lda", trControl=control)
```

```
## Loading required package: MASS
```

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

```
## Loading required package: gbm
```

```
## Warning: package 'gbm' was built under R version 3.2.5
```

```
## 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 2.1.1
```

```
## Loading required package: plyr
```

```
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.0985
##      2        1.5534             nan     0.1000    0.0643
##      3        1.5157             nan     0.1000    0.0480
##      4        1.4875             nan     0.1000    0.0402
##      5        1.4646             nan     0.1000    0.0301
##      6        1.4466             nan     0.1000    0.0350
##      7        1.4266             nan     0.1000    0.0324
##      8        1.4074             nan     0.1000    0.0259
##      9        1.3916             nan     0.1000    0.0239
##     10        1.3775             nan     0.1000    0.0235
##     20        1.2687             nan     0.1000    0.0134
##     40        1.1432             nan     0.1000    0.0084
##     60        1.0623             nan     0.1000    0.0053
##     80        1.0040             nan     0.1000    0.0024
##    100        0.9601             nan     0.1000    0.0026
##    120        0.9230             nan     0.1000    0.0013
##    140        0.8915             nan     0.1000    0.0016
##    150        0.8773             nan     0.1000    0.0009
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.1372
##      2        1.5313             nan     0.1000    0.0963
##      3        1.4755             nan     0.1000    0.0751
##      4        1.4304             nan     0.1000    0.0623
##      5        1.3933             nan     0.1000    0.0586
##      6        1.3592             nan     0.1000    0.0478
##      7        1.3318             nan     0.1000    0.0437
##      8        1.3057             nan     0.1000    0.0333
##      9        1.2852             nan     0.1000    0.0355
##     10        1.2621             nan     0.1000    0.0414
##     20        1.1102             nan     0.1000    0.0132
##     40        0.9375             nan     0.1000    0.0091
##     60        0.8331             nan     0.1000    0.0054
##     80        0.7538             nan     0.1000    0.0035
##    100        0.6932             nan     0.1000    0.0035
##    120        0.6448             nan     0.1000    0.0023
##    140        0.6034             nan     0.1000    0.0024
##    150        0.5844             nan     0.1000    0.0028
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.1660
##      2        1.5151             nan     0.1000    0.1115
##      3        1.4494             nan     0.1000    0.0981
##      4        1.3936             nan     0.1000    0.0920
##      5        1.3404             nan     0.1000    0.0660
##      6        1.2999             nan     0.1000    0.0611
##      7        1.2635             nan     0.1000    0.0484
```

```
##      8        1.2335             nan     0.1000    0.0384
##      9        1.2099             nan     0.1000    0.0443
##     10        1.1827             nan     0.1000    0.0477
##     20        0.9972             nan     0.1000    0.0171
##     40        0.8075             nan     0.1000    0.0081
##     60        0.6942             nan     0.1000    0.0078
##     80        0.6128             nan     0.1000    0.0031
##    100        0.5486             nan     0.1000    0.0032
##    120        0.4965             nan     0.1000    0.0018
##    140        0.4540             nan     0.1000    0.0014
##    150        0.4357             nan     0.1000    0.0011
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.0999
##      2        1.5544             nan     0.1000    0.0675
##      3        1.5171             nan     0.1000    0.0510
##      4        1.4876             nan     0.1000    0.0404
##      5        1.4643             nan     0.1000    0.0378
##      6        1.4425             nan     0.1000    0.0287
##      7        1.4255             nan     0.1000    0.0275
##      8        1.4088             nan     0.1000    0.0266
##      9        1.3923             nan     0.1000    0.0237
##     10        1.3779             nan     0.1000    0.0220
##     20        1.2677             nan     0.1000    0.0153
##     40        1.1403             nan     0.1000    0.0058
##     60        1.0616             nan     0.1000    0.0039
##     80        1.0023             nan     0.1000    0.0026
##    100        0.9579             nan     0.1000    0.0036
##    120        0.9198             nan     0.1000    0.0012
##    140        0.8871             nan     0.1000    0.0014
##    150        0.8715             nan     0.1000    0.0009
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.1374
##      2        1.5317             nan     0.1000    0.0998
##      3        1.4761             nan     0.1000    0.0753
##      4        1.4318             nan     0.1000    0.0616
##      5        1.3960             nan     0.1000    0.0510
##      6        1.3648             nan     0.1000    0.0409
##      7        1.3395             nan     0.1000    0.0410
##      8        1.3148             nan     0.1000    0.0422
##      9        1.2885             nan     0.1000    0.0478
##     10        1.2615             nan     0.1000    0.0317
##     20        1.1065             nan     0.1000    0.0186
##     40        0.9293             nan     0.1000    0.0099
##     60        0.8244             nan     0.1000    0.0052
##     80        0.7486             nan     0.1000    0.0026
##    100        0.6854             nan     0.1000    0.0035
##    120        0.6349             nan     0.1000    0.0022
```

```
##    140        0.5947             nan     0.1000    0.0013
##    150        0.5782             nan     0.1000    0.0013
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.1678
##      2        1.5142             nan     0.1000    0.1182
##      3        1.4437             nan     0.1000    0.0890
##      4        1.3919             nan     0.1000    0.0764
##      5        1.3464             nan     0.1000    0.0611
##      6        1.3095             nan     0.1000    0.0667
##      7        1.2690             nan     0.1000    0.0494
##      8        1.2390             nan     0.1000    0.0543
##      9        1.2063             nan     0.1000    0.0556
##     10        1.1722             nan     0.1000    0.0452
##     20        0.9915             nan     0.1000    0.0250
##     40        0.8013             nan     0.1000    0.0102
##     60        0.6879             nan     0.1000    0.0054
##     80        0.6063             nan     0.1000    0.0044
##    100        0.5442             nan     0.1000    0.0029
##    120        0.4944             nan     0.1000    0.0018
##    140        0.4527             nan     0.1000    0.0013
##    150        0.4346             nan     0.1000    0.0019
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.0961
##      2        1.5532             nan     0.1000    0.0655
##      3        1.5149             nan     0.1000    0.0513
##      4        1.4865             nan     0.1000    0.0391
##      5        1.4645             nan     0.1000    0.0344
##      6        1.4442             nan     0.1000    0.0362
##      7        1.4233             nan     0.1000    0.0289
##      8        1.4062             nan     0.1000    0.0280
##      9        1.3895             nan     0.1000    0.0231
##     10        1.3747             nan     0.1000    0.0239
##     20        1.2623             nan     0.1000    0.0130
##     40        1.1344             nan     0.1000    0.0076
##     60        1.0546             nan     0.1000    0.0045
##     80        0.9995             nan     0.1000    0.0027
##    100        0.9548             nan     0.1000    0.0025
##    120        0.9170             nan     0.1000    0.0018
##    140        0.8860             nan     0.1000    0.0008
##    150        0.8711             nan     0.1000    0.0014
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.1288
##      2        1.5318             nan     0.1000    0.0995
##      3        1.4758             nan     0.1000    0.0768
##      4        1.4302             nan     0.1000    0.0687
##      5        1.3893             nan     0.1000    0.0574
```

```
##      6        1.3552             nan     0.1000    0.0424
##      7        1.3294             nan     0.1000    0.0400
##      8        1.3049             nan     0.1000    0.0432
##      9        1.2789             nan     0.1000    0.0357
##     10        1.2564             nan     0.1000    0.0364
##     20        1.0959             nan     0.1000    0.0145
##     40        0.9299             nan     0.1000    0.0078
##     60        0.8208             nan     0.1000    0.0042
##     80        0.7503             nan     0.1000    0.0032
##    100        0.6859             nan     0.1000    0.0028
##    120        0.6346             nan     0.1000    0.0017
##    140        0.5908             nan     0.1000    0.0018
##    150        0.5722             nan     0.1000    0.0011
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.1686
##      2        1.5126             nan     0.1000    0.1130
##      3        1.4441             nan     0.1000    0.0947
##      4        1.3882             nan     0.1000    0.0814
##      5        1.3405             nan     0.1000    0.0704
##      6        1.2989             nan     0.1000    0.0584
##      7        1.2628             nan     0.1000    0.0479
##      8        1.2333             nan     0.1000    0.0540
##      9        1.2018             nan     0.1000    0.0410
##     10        1.1756             nan     0.1000    0.0357
##     20        0.9906             nan     0.1000    0.0212
##     40        0.8009             nan     0.1000    0.0099
##     60        0.6827             nan     0.1000    0.0089
##     80        0.5998             nan     0.1000    0.0023
##    100        0.5410             nan     0.1000    0.0033
##    120        0.4935             nan     0.1000    0.0016
##    140        0.4504             nan     0.1000    0.0017
##    150        0.4302             nan     0.1000    0.0021
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.1014
##      2        1.5525             nan     0.1000    0.0644
##      3        1.5146             nan     0.1000    0.0513
##      4        1.4854             nan     0.1000    0.0392
##      5        1.4623             nan     0.1000    0.0337
##      6        1.4428             nan     0.1000    0.0351
##      7        1.4219             nan     0.1000    0.0263
##      8        1.4052             nan     0.1000    0.0230
##      9        1.3904             nan     0.1000    0.0263
##     10        1.3733             nan     0.1000    0.0243
##     20        1.2615             nan     0.1000    0.0132
##     40        1.1361             nan     0.1000    0.0063
##     60        1.0568             nan     0.1000    0.0042
##     80        1.0009             nan     0.1000    0.0038
```

```
##    100        0.9545             nan     0.1000    0.0026
##    120        0.9163             nan     0.1000    0.0016
##    140        0.8823             nan     0.1000    0.0017
##    150        0.8681             nan     0.1000    0.0009
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.1342
##      2        1.5309             nan     0.1000    0.0959
##      3        1.4753             nan     0.1000    0.0751
##      4        1.4312             nan     0.1000    0.0646
##      5        1.3938             nan     0.1000    0.0568
##      6        1.3610             nan     0.1000    0.0425
##      7        1.3354             nan     0.1000    0.0405
##      8        1.3107             nan     0.1000    0.0397
##      9        1.2875             nan     0.1000    0.0398
##     10        1.2636             nan     0.1000    0.0405
##     20        1.1060             nan     0.1000    0.0214
##     40        0.9377             nan     0.1000    0.0107
##     60        0.8278             nan     0.1000    0.0041
##     80        0.7510             nan     0.1000    0.0034
##    100        0.6938             nan     0.1000    0.0020
##    120        0.6409             nan     0.1000    0.0024
##    140        0.5976             nan     0.1000    0.0018
##    150        0.5801             nan     0.1000    0.0023
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.1685
##      2        1.5141             nan     0.1000    0.1162
##      3        1.4459             nan     0.1000    0.0985
##      4        1.3875             nan     0.1000    0.0710
##      5        1.3457             nan     0.1000    0.0787
##      6        1.2997             nan     0.1000    0.0676
##      7        1.2610             nan     0.1000    0.0451
##      8        1.2330             nan     0.1000    0.0492
##      9        1.2038             nan     0.1000    0.0486
##     10        1.1752             nan     0.1000    0.0396
##     20        0.9845             nan     0.1000    0.0209
##     40        0.8023             nan     0.1000    0.0104
##     60        0.6882             nan     0.1000    0.0051
##     80        0.6061             nan     0.1000    0.0046
##    100        0.5423             nan     0.1000    0.0047
##    120        0.4875             nan     0.1000    0.0012
##    140        0.4477             nan     0.1000    0.0013
##    150        0.4312             nan     0.1000    0.0025
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.0957
##      2        1.5537             nan     0.1000    0.0673
##      3        1.5162             nan     0.1000    0.0494
```

```
##      4        1.4874             nan     0.1000    0.0390
##      5        1.4641             nan     0.1000    0.0307
##      6        1.4447             nan     0.1000    0.0333
##      7        1.4257             nan     0.1000    0.0276
##      8        1.4090             nan     0.1000    0.0269
##      9        1.3928             nan     0.1000    0.0265
##     10        1.3771             nan     0.1000    0.0235
##     20        1.2690             nan     0.1000    0.0121
##     40        1.1423             nan     0.1000    0.0081
##     60        1.0627             nan     0.1000    0.0049
##     80        1.0034             nan     0.1000    0.0030
##    100        0.9575             nan     0.1000    0.0019
##    120        0.9209             nan     0.1000    0.0022
##    140        0.8880             nan     0.1000    0.0011
##    150        0.8735             nan     0.1000    0.0004
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.1351
##      2        1.5335             nan     0.1000    0.0976
##      3        1.4772             nan     0.1000    0.0727
##      4        1.4351             nan     0.1000    0.0590
##      5        1.3998             nan     0.1000    0.0638
##      6        1.3631             nan     0.1000    0.0461
##      7        1.3347             nan     0.1000    0.0409
##      8        1.3092             nan     0.1000    0.0457
##      9        1.2829             nan     0.1000    0.0364
##     10        1.2597             nan     0.1000    0.0357
##     20        1.1027             nan     0.1000    0.0167
##     40        0.9337             nan     0.1000    0.0114
##     60        0.8302             nan     0.1000    0.0072
##     80        0.7512             nan     0.1000    0.0040
##    100        0.6890             nan     0.1000    0.0031
##    120        0.6343             nan     0.1000    0.0034
##    140        0.5913             nan     0.1000    0.0011
##    150        0.5746             nan     0.1000    0.0011
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        1.6094             nan     0.1000    0.1620
##      2        1.5156             nan     0.1000    0.1191
##      3        1.4454             nan     0.1000    0.0880
##      4        1.3930             nan     0.1000    0.0811
##      5        1.3447             nan     0.1000    0.0688
##      6        1.3032             nan     0.1000    0.0591
##      7        1.2652             nan     0.1000    0.0648
##      8        1.2280             nan     0.1000    0.0444
##      9        1.1996             nan     0.1000    0.0388
##     10        1.1761             nan     0.1000    0.0364
##     20        0.9917             nan     0.1000    0.0143
##     40        0.8013             nan     0.1000    0.0075
```

```
##      60         0.6856             nan     0.1000    0.0051
##      80         0.6053             nan     0.1000    0.0017
##     100         0.5473             nan     0.1000    0.0032
##     120         0.4951             nan     0.1000    0.0020
##     140         0.4532             nan     0.1000    0.0006
##     150         0.4344             nan     0.1000    0.0018
##
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##       1         1.6094             nan     0.1000    0.1648
##       2         1.5162             nan     0.1000    0.1156
##       3         1.4490             nan     0.1000    0.0996
##       4         1.3895             nan     0.1000    0.0776
##       5         1.3436             nan     0.1000    0.0654
##       6         1.3033             nan     0.1000    0.0610
##       7         1.2672             nan     0.1000    0.0577
##       8         1.2345             nan     0.1000    0.0465
##       9         1.2065             nan     0.1000    0.0458
##      10         1.1780             nan     0.1000    0.0398
##      20         0.9922             nan     0.1000    0.0171
##      40         0.8048             nan     0.1000    0.0092
##      60         0.6882             nan     0.1000    0.0053
##      80         0.6076             nan     0.1000    0.0041
##     100         0.5466             nan     0.1000    0.0030
##     120         0.4960             nan     0.1000    0.0022
##     140         0.4595             nan     0.1000    0.0019
##     150         0.4405             nan     0.1000    0.0016
```

```
modelRpart<-train(classe ~ ., data=training, method="rpart", trControl=control)
```

Review the perfomrance of the model

```
predictRF<-predict(modelRF,testing)
predictLDA<-predict(modelLDA,testing)
predictGBM<-predict(modelGBM,testing)
predictRpart<-predict(modelRpart,testing)

confusionMatrix(testing$classe,predictRF)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 2224    1    2    4    1
##          B   42 1464    9    1    2
##          C    0   25 1330    8    5
##          D    1    0   55 1216   14
##          E    2   11    7   16 1406
##
## Overall Statistics
##
##                Accuracy : 0.9737
##                  95% CI : (0.97, 0.9772)
##     No Information Rate : 0.2892
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.9668
##  Mcnemar's Test P-Value : 1.072e-15
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.9802   0.9753   0.9480   0.9767   0.9846
## Specificity            0.9986   0.9915   0.9941   0.9894   0.9944
## Pos Pred Value         0.9964   0.9644   0.9722   0.9456   0.9750
## Neg Pred Value         0.9920   0.9942   0.9887   0.9956   0.9966
## Prevalence             0.2892   0.1913   0.1788   0.1587   0.1820
## Detection Rate         0.2835   0.1866   0.1695   0.1550   0.1792
## Detection Prevalence   0.2845   0.1935   0.1744   0.1639   0.1838
## Balanced Accuracy      0.9894   0.9834   0.9710   0.9831   0.9895
```

```
confusionMatrix(testing$classe,predictLDA)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1468  273  241  167   83
##          B  377  553  153  159  276
##          C  261  120  765   91  131
##          D   94  147  180  691  174
##          E  149  343  285  246  419
##
## Overall Statistics
##
##                Accuracy : 0.4966
##                  95% CI : (0.4854, 0.5077)
##     No Information Rate : 0.2994
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.3625
##  Mcnemar's Test P-Value : < 2.2e-16
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.6249  0.38510   0.4711  0.51034   0.3869
## Specificity            0.8610  0.84945   0.9031  0.90835   0.8487
## Pos Pred Value         0.6577  0.36430   0.5592  0.53733   0.2906
## Neg Pred Value         0.8431  0.86046   0.8674  0.89893   0.8963
## Prevalence             0.2994  0.18302   0.2070  0.17257   0.1380
## Detection Rate         0.1871  0.07048   0.0975  0.08807   0.0534
## Detection Prevalence   0.2845  0.19347   0.1744  0.16391   0.1838
## Balanced Accuracy      0.7430  0.61728   0.6871  0.70934   0.6178
```

```
confusionMatrix(testing$classe,predictGBM)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 2119   26   30   43   14
##          B  138 1193   84   25   78
##          C   20   74 1191   36   47
##          D   22   30  105 1090   39
##          E   13  102   67  139 1121
##
## Overall Statistics
##
##                Accuracy : 0.8557
##                  95% CI : (0.8478, 0.8634)
##     No Information Rate : 0.2947
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.8174
##  Mcnemar's Test P-Value : < 2.2e-16
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.9165   0.8372   0.8064   0.8177   0.8630
## Specificity            0.9796   0.9494   0.9722   0.9699   0.9510
## Pos Pred Value         0.9494   0.7859   0.8706   0.8476   0.7774
## Neg Pred Value         0.9656   0.9633   0.9559   0.9630   0.9722
## Prevalence             0.2947   0.1816   0.1882   0.1699   0.1656
## Detection Rate         0.2701   0.1521   0.1518   0.1389   0.1429
## Detection Prevalence   0.2845   0.1935   0.1744   0.1639   0.1838
## Balanced Accuracy      0.9481   0.8933   0.8893   0.8938   0.9070
```

```
confusionMatrix(testing$classe,predictRpart)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1800   20   66  334   12
##          B  689  198   94  300  237
##          C  600   17  354  381   16
##          D  316   68   23  857   22
##          E  447  169   98  406  322
##
## Overall Statistics
##
##                Accuracy : 0.45
##                  95% CI : (0.439, 0.4611)
##     No Information Rate : 0.491
##     P-Value [Acc > NIR] : 1
##
##                   Kappa : 0.2883
##  Mcnemar's Test P-Value : <2e-16
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.4673  0.41949  0.55748   0.3762  0.52874
## Specificity            0.8918  0.82099  0.85938   0.9230  0.84524
## Pos Pred Value         0.8065  0.13043  0.25877   0.6664  0.22330
## Neg Pred Value         0.6345  0.95670  0.95662   0.7834  0.95518
## Prevalence             0.4910  0.06016  0.08093   0.2903  0.07762
## Detection Rate         0.2294  0.02524  0.04512   0.1092  0.04104
## Detection Prevalence   0.2845  0.19347  0.17436   0.1639  0.18379
## Balanced Accuracy      0.6796  0.62024  0.70843   0.6496  0.68699
```

```
accuracyRF<-postResample(predictRF,testing$classe)
accuracyLDA<-postResample(predictLDA,testing$classe)
accuracyGBM<-postResample(predictGBM,testing$classe)
accuracyRpart<-postResample(predictRpart,testing$classe)

accuracyRF
```

```
##  Accuracy     Kappa
## 0.9737446 0.9667688
```

```
accuracyLDA
```

```
##  Accuracy     Kappa
## 0.4965588 0.3624725
```

```
accuracyGBM
```

```
##  Accuracy     Kappa
## 0.8557227 0.8173557
```

```
accuracyRpart
```

```
##  Accuracy     Kappa
## 0.4500382 0.2882895
```

It shows that the highest accuracy of random forest model is 97.50%.

6.Predict Predict by using testing data

```
model <- train(classe ~ ., data=training, method="rf", trControl=control, ntree
=250)
result <- predict(model, training[, -length(names(training))])
result
```

```
##    [1] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##   [35] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##   [69] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [103] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [137] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [171] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [205] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [239] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [273] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [307] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [341] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
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##  [681] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [715] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [749] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [783] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [817] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [851] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [885] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [919] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [953] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
##  [987] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
## [1021] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
## [1055] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
## [1089] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
## [1123] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
## [1157] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
## [1191] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
## [1225] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
## [1259] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
## [1293] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
## [1327] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
## [1361] A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A A
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##  [8059] D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D
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##  [8195] D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D
##  [8229] D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D
##  [8263] D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D
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##  [8297] D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D
##  [8331] D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D
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##  [8467] D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D
##  [8501] D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D
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##  [9555] D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D D
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##  [9691] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
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##  [9861] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
##  [9895] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
##  [9929] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
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##  [9963] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
##  [9997] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [10031] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [10065] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [10099] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
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## [10167] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
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## [10677] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [10711] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [10745] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
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## [10881] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
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## [10983] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11017] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11051] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11085] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11119] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11153] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11187] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11221] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11255] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11289] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11323] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11357] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11391] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11425] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11459] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11493] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11527] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11561] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
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## [11663] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11697] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11731] E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E E
## [11765] E E E E E E E E E E E
## Levels: A B C D E
```

```
#Considering the length, this part will not be shown
```

7.Answer the asked question

```
pml_write_files = function(x){
  n = length(x)
  for(i in 1:n){
    filename = paste0("problem_id_",i,".txt")
    write.table(x[i],file=filename,quote=FALSE,row.names=FALSE,col.names=FALSE)
  }
}

testing_data <- testing_data[featureset[featureset!='classe']]
answers <- predict(model, newdata=testing_data)
answers
```

```
##  [1] B A B A A E D B A A B C B A E E A B B B
## Levels: A B C D E
```

```
pml_write_files(answers)
```