WLE_classification.R, Feature selections

1. Use the below given data set
DataSet
2. Perform the below given activities:
a. Create classification model using different classifiers
b. Verify model goodness of fit

c. Apply all the model validation techniques.

The *Weight Lifting Exercises (WLE)* dataset is used to investigate *how well* an activity is being performed. Six participants were performing one set of 10 repetitions of the *Unilateral Dumbbell Biceps Curl* in *five* different fashions:

- Class A - exactly according to the specification,
- Class B - throwing the elbows to the front,
- Class C - lifting the dumbbell only halfway,
- Class D - lowering the dumbbell only halfway,
- Class E - throwing the hips to the front.

Class A corresponds to the specified execution of the exercise, while the other 4 classes correspond to common mistakes

The outcome of the given classification problem is given by the variable `classes` in the last column which is a factor variable with 5 levels “A”,“B”,“C”,“D”, and “E”. Each class is sufficiently represented in the training dataset. The outcome variable `classes`, however, is not included in the test dataset where it is replaced by a variable `problem_id` for identification purposes of the 20 test cases for the submission of the prediction results. Both datasets are consistent in their variable names (except for the last column with the outcome `classe` in the training dataset and `problem_id` in test dataset) and contain a considerable number of *missing values* marked as NA.

For feature extraction we only use the variables which are related to the raw measurements from the sensors located on the belt, forearm, arm, and dumbbell for the physical movement during the exercise.

A quick verification shows that the reduced training (`trainPredSet`) and test (`testPredSet`) datasets are consistent in their predictor variable names and have no missing values (NAs).

In order to evaluate our prediction algorithm cross-validation is used. The training set is split into a cross-validation training set `cvTrain` (80%) and test set `cvTest` (20%). So we can train our model on the `cvTrain` dataset and test the accuracy of our prediction on the `cvTest` dataset in order to evaluate the influence of different training methods, predictor selections and predictor preprocessing methods. A high number of training examples (80%) is chosen to optimize for the training of the model.

When using the described prediction model to predict the 20 different test cases from the original test dataset `testing` we obtain 20 predictions as output .

```r
setwd("C:/Users/Shraddha/Desktop/sv R related/acadgild/assignments/session19
As signment")
WLE<- read.csv("WLE.csv",header=T, na.strings=c("","NA"))
data<-WLE
View(data)
summary(data)

summary(data$classe)

names(data)

library(devtools)
install_github('adam-m-mcelhinney/helpRFunctions')

library(helpRFunctions)

training<-data[1:4000,]
testing<-data[4001:4024,]
dim(training)

summary(training)

str(training)

predictorIdx <- c(grep("^accel", names(training)), grep("^gyros", names(train
ing)),
                  grep("^magnet", names(training)), grep("^roll", names(train
ing)), grep("^pitch", names(training)), grep("^yaw", names(training)), grep(
"^total", names(training)))

trainPredSet <- training[, c(predictorIdx, 157)]

testPredSet <- testing[, c(predictorIdx, 157)]
length(predictorIdx)

sum(names(testing)[predictorIdx] != names(training)[predictorIdx])

#sum(is.na(trainPredSet)) color = trainPredSet$classe)
nearZeroVar(trainPredSet[, -7], saveMetric = TRUE)

qplot(x = trainPredSet[, "accel_belt_x"], y = trainPredSet[, "accel_arm_x"],c
olor = trainPredSet$classe)



set.seed(125)
inTrain <- createDataPartition(y = trainPredSet$classe, p = 0.8, list = FALSE
```

```
)
cvTrain <- trainPredSet[inTrain, ]
cvTest <- trainPredSet[-inTrain, ]
fitCtrl <- trainControl(method = "repeatedcv", number = 10, repeats = 10)
set.seed(125)
modFit <- train(classe ~ ., data = cvTrain, method = "qda", preProcess = c("c
enter","scale"), trControl = fitCtrl)

print(modFit)

ptrain <- predict(modFit, newdata = cvTrain)
equalPredTrain <- (ptrain == cvTrain$classe)
print(sum(equalPredTrain)/length(equalPredTrain))

confusionMatrix(data = ptrain, reference = cvTrain$classe)

ptest <- predict(modFit, newdata = cvTest)
equalPredTest <- (ptest == cvTest$classe)
print(sum(equalPredTest)/length(equalPredTest))

testPrediction <- predict(modFit, newdata = testing)
print(rbind(testing[1:20, 157], as.character(testPrediction)))
```

```r
setwd("C:/Users/Shraddha/Desktop/sv R related/acadgild/assignments/session19
As signment")
WLE<- read.csv("WLE.csv",header=T, na.strings=c("","NA"))
data<-WLE
View(data)
summary(data)
```

```
##    user_name    raw_timestamp_part_1  raw_timestamp_part_2
## adelmo : 311 Min. :1.322e+09 Min. :  297
##  carlitos:1580   1st  Qu.:1.323e+09   1st  Qu.:244321
##   eurico   :   88   Median :1.323e+09    Median :492342
##  jeremy   :   4   Mean   :1.323e+09    Mean    490377
##   pedro   :2041    3rd Qu.:1.323e+09    3rd Qu.:736278
##                   Max.   :1.323e+09    Max.    996453
##
##           cvtd_timestamp new_window   num_window      roll_belt
##  2/12/2011 13:35 : 311   no :3936   Min.   : 1.00   Min.   :-28.90
##  28/11/2011 14:15:  88   yes:  88   1st Qu.:24.00   1st Qu.:  1.38
##  30/11/2011 17:12:   4              Median :46.00   Median :122.00
##  5/12/2011 11:23 : 337              Mean   :46.33   Mean   : 73.31
##  5/12/2011 11:25 :1243              3rd Qu.:69.00   3rd Qu.:124.00
##  5/12/2011 14:22 : 456              Max.   :91.00   Max.   :159.00
##  5/12/2011 14:23 :1585
##    pitch_belt        yaw_belt        total_accel_belt kurtosis_roll_belt
##  Min.   :-56.20   Min.   :-179.000   Min.   : 0.00    Min.   :-3.333
##  1st Qu.:  6.22   1st Qu.: -93.100   1st Qu.: 3.00    1st Qu.:-1.036
##  Median : 25.50   Median :  -4.940   Median :19.00    Median :-1.036
##  Mean   : 14.16   Mean   : -30.975   Mean   :12.77    Mean   :-1.027
##  3rd Qu.: 26.40   3rd Qu.:  -2.695   3rd Qu.:20.00    3rd Qu.:-1.036
##  Max.   : 60.30   Max.   : 179.000   Max.   :26.00    Max.   : 7.515
##
##  kurtosis_picth_belt skewness_roll_belt  skewness_roll_belt.1
##  Min.   :-2.1212     Min.   :-3.031527   Min.   :-6.63325
##  1st Qu.:-0.3913     1st Qu.: 0.005406   1st Qu.: 0.04512
##  Median :-0.3913     Median : 0.005406   Median : 0.04512
##  Mean   :-0.3496     Mean   : 0.003858   Mean   : 0.04011
##  3rd Qu.:-0.3913   3rd Qu.: 0.005406    3rd Qu.: 0.04512
##  Max.   :54.0000    Max.   : 2.713152    Max.   : 7.34847
##
##  max_roll_belt     max_picth_belt   max_yaw_belt     min_roll_belt
##  Min.   :-94.400   Min.   : 3.00   Min.   :-3.3000   Min.   :-179.000
##  1st Qu.: -4.100   1st Qu.:20.00   1st Qu.:-1.0000   1st Qu.:  -7.250
##  Median : -4.100   Median :20.00   Median :-1.0000   Median :  -7.250
```

```
##  Mean   : -4.626   Mean   :19.87   Mean   :-0.9917   Mean   :  -7.838
##  3rd Qu.: -4.100   3rd Qu.:20.00   3rd Qu.:-1.0000   3rd Qu.:  -7.250
##  Max.   :179.000   Max.   :26.00   Max.   : 7.5000   Max.   : 157.000
##
##  min_pitch_belt   min_yaw_belt     amplitude_roll_belt
##  Min.   : 0.00   Min.   :-3.3000   Min.   :  0.000
##  1st Qu.:18.00   1st Qu.:-1.0000   1st Qu.:  1.345
##  Median :18.00   Median :-1.0000   Median :  1.345
##  Mean   :17.86   Mean   :-0.9917    Mean    :  1.446
##  3rd  Qu.:18.00  3rd  Qu.:-1.0000  3rd  Qu.:   1.345
##  Max.   :20.00   Max.   : 7.5000   Max.   :358.000
##
##  amplitude_pitch_belt amplitude_yaw_belt var_total_accel_belt
##  Min.   : 0.000       Min.    0          Min.   : 0.0000
##  1st Qu.: 2.000       1st Qu.:0          1st Qu.: 0.3000
##  Median : 2.000       Median :0          Median : 0.3000
##  Mean   : 2.014       Mean    0          Mean   : 0.3148
##  3rd Qu.: 2.000       3rd Qu.:0          3rd Qu.: 0.3000
##  Max.   :21.000        Max.   :0         Max.   :18.2000
##
##   avg_roll_belt    stddev_roll_belt var_roll_belt    avg_pitch_belt
##   Min.   :-27.4   Min.    :0.0000   Min.    : 0.0000   Min.    :-49.40
##   1st Qu.:121.9   1st Qu.:0.6000   1st Qu.: 0.3500   1st Qu.: 25.75
##   Median :121.9   Median :0.6000   Median : 0.3500   Median : 25.75
##   Mean   :120.8   Mean    :0.6257   Mean    : 0.5371   Mean    : 25.49
##   3rd Qu.:121.9   3rd Qu.:0.6000   3rd Qu.: 0.3500   3rd Qu.: 25.75
##   Max.   :154.5   Max.    :8.5000   Max.    :71.8000   Max.    : 59.70
##
##   stddev_pitch_belt var_pitch_belt     avg_yaw_belt     stddev_yaw_belt
##   Min.    :0.0000    Min.    : 0.0000   Min.    :-94.400   Min.    :  0.0000
##   1st Qu.:0.3500    1st Qu.: 0.1000   1st Qu.: -4.950   1st Qu.:  0.4000
##   Median :0.3500    Median : 0.1000   Median : -4.950   Median :  0.4000
##   Mean   :0.3573    Mean    : 0.1288   Mean    : -5.515   Mean    :  0.4449
##   3rd Qu.:0.3500   3rd Qu.: 0.1000   3rd Qu.: -4.950   3rd Qu.:  0.4000
##   Max.   :6.2000    Max.    :39.0000   Max.    :158.600   Max.    :163.1000
##
## var_yaw_belt gyros_belt_x  gyros_belt_y
##   Min.   :    0.000    Min.    :-0.7900    Min.    :-0.470000
##   1st Qu.:    0.170    1st Qu.:-0.4300    1st Qu.:-0.030000
##   Median :    0.170    Median :-0.2400    Median :-0.020000
##   Mean   :    6.796    Mean    :-0.1823    Mean    :-0.008837
##   3rd Qu.:   0.170    3rd Qu.: 0.0200    3rd Qu.: 0.000000
##   Max.   :26610.320   Max.    : 2.0200    Max.    : 0.420000
##
##    gyros_belt_z       accel_belt_x      accel_belt_y     accel_belt_z
##   Min.    :-0.7700    Min.    :-120.00   Min.    :-71.00   Min.    :-244.00
##   1st Qu.:-0.4600    1st Qu.: -42.00   1st Qu.:  4.00   1st Qu.:-176.00
##   Median :-0.4100    Median : -34.00   Median : 65.00   Median :-166.00
##   Mean    :-0.2464    Mean    : -24.36   Mean    : 39.84   Mean    : -94.73
##   3rd Qu.:-0.0200    3rd Qu.: -16.00   3rd Qu.: 70.00   3rd Qu.:  20.00
```

```
##  Max.   : 0.8200   Max.   :  80.00   Max.   :164.00   Max.   :  77.00
##
##  magnet_belt_x    magnet_belt_y   magnet_belt_z       roll_arm
##  Min.   :-30.00   Min.   :428.0   Min.   :-513.0   Min.   :-180.00
##  1st Qu.: -3.00   1st Qu.:577.0   1st Qu.:-379.0   1st Qu.: -34.40
##  Median :  2.00   Median :585.0   Median :-366.0   Median :  72.10
##  Mean   : 24.65   Mean   :582.7   Mean   :-340.9   Mean   :  40.01
##  3rd Qu.:  8.00   3rd Qu.:601.0   3rd Qu.:-311.0   3rd Qu.: 124.00
##  Max.   :485.00   Max.   :652.0   Max.   : 293.0   Max.   : 180.00
##
##    pitch_arm          yaw_arm         total_accel_arm var_accel_arm
##  Min.   :-87.100   Min.   :-180.000   Min.   : 1.00   Min.   :  0.00
##  1st Qu.:-32.200   1st Qu.: -59.675   1st Qu.:15.00   1st Qu.: 65.10
##  Median : -8.645   Median :  17.500   Median :25.00   Median : 65.10
##  Mean   :-10.539   Mean   :   2.768   Mean   :24.89   Mean   : 65.28
##  3rd Qu.: 14.600   3rd Qu.:  72.825   3rd Qu.:34.00   3rd Qu.: 65.10
##  Max.   : 81.400   Max.   : 180.000   Max.   :59.00   Max.   :253.01
##
##   avg_roll_arm     stddev_roll_arm   var_roll_arm     avg_pitch_arm
##  Min.   :-169.69   Min.   :  0.00   Min.   :    0.0   Min.   :-57.29
##  1st Qu.:  76.22   1st Qu.: 16.10   1st Qu.:  259.4   1st Qu.:-10.17
##  Median :  76.22   Median : 16.10   Median :  259.4   Median :-10.17
##  Mean   :  75.37   Mean   : 16.23   Mean   :  283.6   Mean   :-10.15
##  3rd Qu.:  76.22   3rd Qu.: 16.10   3rd Qu.:  259.4   3rd Qu.:-10.17
##  Max.   : 160.78   Max.   :161.96   Max.   :26232.2   Max.   : 54.60
##
##   stddev_pitch_arm var_pitch_arm     avg_yaw_arm     stddev_yaw_arm
##  Min.   : 0.00    Min.   :  0.0   Min.   :-164.64   Min.   :  0.00
##  1st Qu.:10.67    1st Qu.:113.8   1st Qu.:  19.06   1st Qu.: 35.88
##  Median :10.67    Median :113.8   Median :  19.06   Median : 35.88
##  Mean   :10.70    Mean   :116.1   Mean   :  18.70   Mean   : 35.90
##  3rd Qu.:10.67    3rd Qu.:113.8   3rd Qu.:  19.06   3rd Qu.: 35.88
##  Max.   :30.78    Max.   :947.3   Max.   : 148.45   Max.   :177.04
##
## var_yaw_arm gyros_arm_x gyros_arm_y  gyros_arm_z
##  Min.   :    0   Min.   :-5.2000   Min.   :-3.4400   Min.   :-2.17000
##  1st Qu.: 1287   1st Qu.:-2.0925   1st Qu.:-0.9200   1st Qu.:-0.20000
##  Median : 1287   Median :-0.0200   Median :-0.0300   Median : 0.00000
##  Mean   : 1307   Mean   :-0.1852   Mean   :-0.1818   Mean   : 0.04444
##  3rd Qu.: 1287   3rd Qu.: 1.7000   3rd Qu.: 0.5800   3rd Qu.: 0.28000
##  Max.   :31345   Max.   : 4.3400   Max.   : 2.4600   Max.   : 3.02000
##
##   accel_arm_x       accel_arm_y       accel_arm_z       magnet_arm_x
##  Min.   :-346.00   Min.   :-252.00   Min.   :-538.00   Min.   :-515.0
##  1st Qu.: -88.00   1st Qu.: -21.00   1st Qu.:-124.00   1st Qu.:-332.0
##  Median :  24.00   Median :  22.00   Median :   6.00   Median : 278.5
##  Mean   :  34.38   Mean   :  26.87   Mean   : -41.39   Mean   : 194.3
##  3rd Qu.: 136.00   3rd Qu.:  96.25   3rd Qu.:  76.00   3rd Qu.: 651.0
##  Max.   : 434.00   Max.   : 229.00   Max.   : 209.00   Max.   : 782.0
##
```

```
##   magnet_arm_y     magnet_arm_z    kurtosis_roll_arm kurtosis_picth_arm
##  Min.   :-392.0   Min.   :-573.0   Min.   :-3.333    Min.   :-2.0835
##  1st Qu.: -13.0   1st Qu.:  -1.0   1st Qu.:-1.182    1st Qu.:-0.9691
##  Median : 267.0   Median : 431.0   Median :-1.182    Median :-0.9691
##  Mean   : 161.7   Mean   : 253.2   Mean   :-1.172    Mean   :-0.9507
##  3rd Qu.: 348.0   3rd Qu.: 515.0   3rd Qu.:-1.182    3rd Qu.:-0.9691
##  Max.   : 482.0   Max.   : 647.0   Max.   :18.719    Max.   :23.8408
##
##  kurtosis_yaw_arm  skewness_roll_arm  skewness_pitch_arm  skewness_yaw_arm
##  Min.   :-1.6308   Min.   :-1.7457   Min.   :-4.9942   Min.   :-6.00000
##  1st Qu.:-0.8698   1st Qu.: 0.1235   1st Qu.:-0.1032   1st Qu.: 0.05976
##  Median :-0.8698   Median : 0.1235   Median :-0.1032   Median : 0.05976
##  Mean   :-0.8481   Mean   : 0.1246   Mean   :-0.1058   Mean   : 0.05742
##  3rd Qu.:-0.8698   3rd Qu.: 0.1235   3rd Qu.:-0.1032   3rd Qu.: 0.05976
##  Max.   :36.0000   Max.   : 4.3945   Max.   : 2.1711   Max.   : 2.10699
##
##   max_roll_arm     max_picth_arm      max_yaw_arm  min_roll_arm
##  Min.   :-36.300   Min.   :-164.00   Min.   : 3   Min.   :-87.10
##  1st Qu.:  8.450   1st Qu.:  77.25   1st Qu.:38   1st Qu.:-33.60
##  Median :  8.450   Median :  77.25   Median :38   Median :-33.60
##  Mean   :  8.478   Mean   :  76.79   Mean   :38   Mean   :-33.47
##  3rd Qu.:  8.450   3rd Qu.:  77.25   3rd Qu.:38   3rd Qu.:-33.60
##  Max.   : 81.400   Max.   : 180.00   Max.   :59   Max.   : 35.70
##
##  min_pitch_arm      min_yaw_arm    amplitude_roll_arm amplitude_pitch_arm
##  Min.   :-180.00   Min.   : 1.00   Min.   : 0.00      Min.   :  0.0
##  1st Qu.: -58.60   1st Qu.:10.00   1st Qu.:36.95      1st Qu.:121.5
##  Median : -58.60   Median :10.00   Median :36.95      Median :121.5
##  Mean   : -58.53   Mean   :10.06   Mean   :36.96      Mean   :121.3
##  3rd Qu.: -58.60   3rd Qu.:10.00   3rd Qu.:36.95      3rd Qu.:121.5
##  Max.   : 146.00   Max.   :34.00   Max.   :90.00      Max.   :360.0
##
##  amplitude_yaw_arm roll_dumbbell      pitch_dumbbell     yaw_dumbbell
##  Min.   : 0.00     Min.   :-152.782   Min.   :-134.73   Min.   :-129.33
##  1st Qu.:27.00     1st Qu.: -34.657   1st Qu.: -12.93   1st Qu.:  21.35
##  Median :27.00     Median :  -2.295   Median :  14.48   Median :  72.49
##  Mean   :26.96     Mean   :   3.500   Mean   :   5.18   Mean   :  55.66
##  3rd Qu.:27.00     3rd Qu.:  58.014   3rd Qu.:  27.95   3rd Qu.: 122.01
##  Max.   :52.00     Max.   : 139.729   Max.   :  97.28   Max.   : 152.92
##
##  kurtosis_roll_dumbbell kurtosis_picth_dumbbell kurtosis_yaw_dumbbell
##  Min.   :-2.08890       Min.   :-2.0889         Mode:logical
##  1st Qu.:-0.09595       1st Qu.:-0.4422         NA's:4024
##  Median :-0.09595       Median :-0.4422
##  Mean   :-0.08668       Mean   :-0.4313
##  3rd Qu.:-0.09595       3rd Qu.:-0.4422
##  Max.   : 7.56330       Max.   :11.2734
##
##  skewness_roll_dumbbell skewness_pitch_dumbbell skewness_yaw_dumbbell
## Min. :-2.61100 Min. :-2.0501  Mode:logical
```

```
## 1st Qu.: 0.08190 1st Qu.:-0.2160  NA's:4024
## Median : 0.08190 Median :-0.2160
##  Mean   : 0.08043      Mean   :-0.2133
##  3rd Qu.: 0.08190      3rd Qu.:-0.2160
##  Max.   : 2.38140      Max.   : 2.7832
##
##  max_roll_dumbbell max_picth_dumbbell max_yaw_dumbbell   min_roll_dumbbell
##  Min.   :-70.90    Min.   :-84.5      Min.   :-2.10000   Min.   :-134.70
##  1st Qu.: 41.85    1st Qu.:133.0      1st Qu.:-0.10000   1st Qu.: -26.75
##  Median : 41.85    Median :133.0      Median :-0.10000   Median : -26.75
##  Mean   : 41.68    Mean   :132.0    Mean   :-0.09058   Mean   : -26.77
##  3rd Qu.: 41.85    3rd Qu.:133.0    3rd Qu.:-0.10000   3rd Qu.: -26.75
##  Max.   : 97.30    Max.   :152.9    Max.   : 7.60000   Max.   :  26.80
##
##  min_pitch_dumbbell min_yaw_dumbbell   amplitude_roll_dumbbell
##  Min.   :-129.3     Min.   :-2.10000   Min.   :  0.00
##  1st Qu.:  20.2     1st Qu.:-0.10000   1st Qu.: 55.71
##  Median :  20.2     Median :-0.10000   Median : 55.71
##  Mean   :  20.1    Mean   :-0.09058   Mean   : 55.84
##  3rd Qu.:  20.2    3rd Qu.:-0.10000   3rd Qu.: 55.71
##  Max.   : 122.9    Max.   : 7.60000   Max.   :171.75
##
##  amplitude_pitch_dumbbell amplitude_yaw_dumbbell total_accel_dumbbell
##  Min.   :  0.00           Min.   :0              Min.   : 1.00
##  1st Qu.: 54.74           1st Qu.:0              1st Qu.: 6.00
##  Median : 54.74           Median :0              Median : 9.00
##  Mean   : 55.13           Mean   :0              Mean   :12.02
##  3rd Qu.: 54.74           3rd Qu.:0              3rd Qu.:14.00
##  Max.   :217.33           Max.   :0              Max.   :37.00
##                           NA's    3936
##  var_accel_dumbbell avg_roll_dumbbell  stddev_roll_dumbbell
##  Min.   :  0.000    Min.   :-110.933   Min.   :  0.00
##  1st Qu.:  2.416    1st Qu.:  -5.118   1st Qu.: 17.06
##  Median :  2.416  Median :  -5.118    Median : 17.06
##  Mean   :  2.571   Mean   :  -4.948    Mean   : 17.26
##  3rd Qu.:  2.416  3rd Qu.:  -5.118    3rd Qu.: 17.06
##  Max.   :230.428   Max.   : 117.404    Max.   :103.12
##
##  var_roll_dumbbell avg_pitch_dumbbell stddev_pitch_dumbbell
##  Min.   :    0.0   Min.   :-70.92     Min.   : 0.00
##  1st Qu.:  291.0   1st Qu.: 13.93     1st Qu.:14.11
##  Median :  291.0   Median : 13.93     Median :14.11
##  Mean   :  314.4    Mean   : 13.70    Mean   :14.13
##  3rd Qu.:  291.0    3rd Qu.: 13.93    3rd Qu.:14.11
##  Max.   :10634.5    Max.   : 57.45    Max.   :48.43
##
##  var_pitch_dumbbell avg_yaw_dumbbell  stddev_yaw_dumbbell var_yaw_dumbbell
##  Min.   :   0.0     Min.   :-105.65   Min.   : 0.00       Min.   :   0.0
##  1st Qu.: 199.1     1st Qu.:  64.71   1st Qu.:13.57       1st Qu.: 184.6
##  Median : 199.1     Median :  64.71   Median :13.57       Median : 184.6
```

```
##  Mean   : 202.2     Mean   :  64.41   Mean   :13.69       Mean   : 193.2
##  3rd Qu.: 199.1     3rd Qu.:  64.71   3rd Qu.:13.57       3rd Qu.: 184.6
##  Max.   :2345.4     Max.   : 129.93   Max.   :71.06       Max.   :5049.5
##
##  gyros_dumbbell_x  gyros_dumbbell_y   gyros_dumbbell_z  accel_dumbbell_x
##  Min.   :-1.4300   Min.   :-2.04000   Min.   :-1.4600   Min.   :-237.000
##  1st Qu.:-0.0200   1st Qu.:-0.27000   1st Qu.:-0.3300   1st Qu.:  -6.000
##  Median : 0.3200   Median :-0.06000   Median :-0.1300   Median :  11.000
##  Mean   : 0.2487   Mean   :-0.04674   Mean   :-0.1337   Mean   :  -7.091
##  3rd Qu.: 0.5300   3rd Qu.: 0.14000   3rd Qu.: 0.0500   3rd Qu.:  23.000
##  Max.   : 1.4800   Max.   : 4.37000   Max.   : 1.8900   Max.   : 217.000
##
##  accel_dumbbell_y  accel_dumbbell_z  magnet_dumbbell_x magnet_dumbbell_y
##  Min.   :-163.00   Min.   :-273.00   Min.   :-638.00   Min.   :-730.0
##  1st Qu.: -28.00   1st Qu.:  12.00   1st Qu.:-515.00   1st Qu.:-544.0
##  Median :  -2.00   Median :  51.00   Median : 107.50   Median :-486.0
##  Mean   :  12.83   Mean   :  16.63   Mean   :  10.55   Mean   :-115.7
##  3rd Qu.:  47.00   3rd Qu.:  79.00   3rd Qu.: 506.00   3rd Qu.: 304.0
##  Max.   : 281.00   Max.   : 122.00   Max.   : 579.00   Max.   : 618.0
##
##  magnet_dumbbell_z  roll_forearm    pitch_forearm     yaw_forearm
##  Min.   :-262.00   Min.   :-180.0   Min.   :-64.00   Min.   :-180.00
##  1st Qu.:-101.00   1st Qu.:-115.0   1st Qu.:  0.00   1st Qu.:-106.00
##  Median : -59.00   Median :  89.5   Median : 19.70   Median :  83.50
##  Mean   : -41.12   Mean   :  36.1   Mean   : 18.57   Mean   :  17.79
##  3rd Qu.:   1.00   3rd Qu.: 136.0   3rd Qu.: 43.90   3rd Qu.: 108.00
##  Max.   : 300.00   Max.   : 180.0   Max.   : 86.90   Max.   : 180.00
##
##  kurtosis_roll_forearm kurtosis_picth_forearm kurtosis_yaw_forearm
##  Min.   :-1.796        Min.   :-6.0000        Mode:logical
##  1st Qu.:-1.095        1st Qu.:-0.9752        NA's:4024
##  Median :-1.095        Median :-0.9752
##  Mean   :-1.088        Mean   :-0.9469
##  3rd Qu.:-1.095        3rd Qu.:-0.9752
##  Max.   : 6.651        Max.   :28.5654
##
##  skewness_roll_forearm skewness_pitch_forearm skewness_yaw_forearm
##  Min.   :-1.71990      Min.   :-4.5751        Mode:logical
##  1st Qu.:-0.05065      1st Qu.: 0.1729        NA's:4024
##  Median :-0.05065      Median : 0.1729
##  Mean   :-0.04793      Mean   : 0.1686
##  3rd Qu.:-0.05065      3rd Qu.: 0.1729
##  Max.   : 2.23660      Max.   : 3.5998
##
##  max_roll_forearm max_picth_forearm max_yaw_forearm  min_roll_forearm
##  Min.   :-63.90   Min.   :-152.0    Min.   :-1.800   Min.   :-64.000
##  1st Qu.: 49.60   1st Qu.: 168.0    1st Qu.:-1.100   1st Qu.:  4.650
##  Median : 49.60   Median : 168.0    Median :-1.100   Median :  4.650
##  Mean   : 49.25   Mean   : 166.8    Mean   :-1.093   Mean   :  4.614
##  3rd Qu.: 49.60   3rd Qu.: 168.0    3rd Qu.:-1.100   3rd Qu.:  4.650
```

```
##  Max.   : 86.90   Max.   : 180.0    Max.   : 6.700   Max.   : 47.500
##
##  min_pitch_forearm min_yaw_forearm  amplitude_roll_forearm
##  Min.   :-180.0    Min.   :-1.800   Min.   : 0.00
##  1st Qu.:-168.5    1st Qu.:-1.100   1st Qu.:32.20
##  Median :-168.5    Median :-1.100   Median :32.20
##  Mean   :-166.6    Mean   :-1.093   Mean   :32.16
##  3rd Qu.:-168.5    3rd Qu.:-1.100   3rd Qu.:32.20
##  Max.   : 125.0    Max.   : 6.700   Max.   :77.10
##
##  amplitude_pitch_forearm amplitude_yaw_forearm total_accel_forearm
##  Min.   :  0.0           Min.   :0             Min.   :10.00
##  1st Qu.:341.5           1st Qu.:0             1st Qu.:30.00
##  Median :341.5           Median :0             Median :35.00
##  Mean   :338.3           Mean   :0             Mean   :34.38
##  3rd Qu.:341.5           3rd Qu.:0             3rd Qu.:37.00
##  Max.   :359.0           Max.   :0             Max.   :59.00
##                          NA's    3944
##  var_accel_forearm avg_roll_forearm  stddev_roll_forearm var_roll_forearm
##  Min.   :  0.00    Min.   :-145.14   Min.   :  0.00      Min.   :    0
##  1st Qu.: 14.08    1st Qu.:  27.86   1st Qu.: 45.16      1st Qu.: 2749
##  Median : 14.08    Median :  27.86   Median : 45.16      Median : 2749
##  Mean   : 14.43    Mean   :  28.13   Mean   : 45.66      Mean   : 2889
##  3rd Qu.: 14.08    3rd Qu.:  27.86   3rd Qu.: 45.16      3rd Qu.: 2749
##  Max.   :124.18    Max.   : 151.25   Max.   :176.48      Max.    31145
##
##  avg_pitch_forearm stddev_pitch_forearm var_pitch_forearm
##  Min.   :-63.90    Min.   : 0.000       Min.   :  0.00
##  1st Qu.: 25.36    1st Qu.: 8.907       1st Qu.: 79.33
##  Median : 25.36    Median : 8.907       Median : 79.33
##  Mean   : 25.18    Mean   : 8.921       Mean   : 80.97
##  3rd Qu.: 25.36    3rd Qu.: 8.907       3rd Qu.: 79.33
##  Max.   : 68.17    Max.   :26.729       Max.   :714.45
##
## avg_yaw_forearm   stddev_yaw_forearm  var_yaw_forearm  gyros_forearm_x
##  Min.   :-152.33   Min.   :  0.00   Min.   :    0   Min.   :-1.8800
##  1st Qu.:  17.10   1st Qu.: 74.28     1st Qu.: 5542   1st Qu.:-0.1400
##  Median :  17.10   Median : 74.28     Median : 5542   Median : 0.0600
##  Mean   :  17.13   Mean   : 74.01     Mean   : 5578   Mean   : 0.1076
##  3rd Qu.:  17.10   3rd Qu.: 74.28     3rd Qu.: 5542   3rd Qu.: 0.4200
##  Max.   : 132.59   Max.   :197.51     Max.   :39009   Max.   : 1.8100
##
##  gyros_forearm_y     gyros_forearm_z    accel_forearm_x
##  Min.   :-5.730000   Min.   :-2.58000   Min.   :-328.000
##  1st Qu.:-1.780000   1st Qu.:-0.31000   1st Qu.:-117.000
##  Median :-0.020000   Median :-0.02000   Median :  -6.000
##  Mean   :-0.004108   Mean   : 0.09302   Mean   :  -6.445
##  3rd Qu.: 1.830000   3rd Qu.: 0.48000   3rd Qu.: 113.000
##  Max.   : 5.170000   Max.   : 3.35000   Max.   : 279.000
##
```

```
##  accel_forearm_y   accel_forearm_z magnet_forearm_x  magnet_forearm_y
##  Min.   :-467.00   Min.   :-366    Min.   :-1160.0   Min.   :-725.0
##  1st Qu.:  75.75   1st Qu.:-210    1st Qu.: -589.0   1st Qu.: -76.0
##  Median : 229.50   Median :-181    Median : -330.5   Median : 653.0
##  Mean   : 171.47   Mean   :-163    Mean   : -348.7   Mean   : 358.6
##  3rd Qu.: 297.00   3rd Qu.:-150    3rd Qu.: -152.0   3rd Qu.: 747.0
##  Max.   : 575.00   Max.   : 239    Max.   :  413.0   Max.   :1440.0
##
##  magnet_forearm_z classe
##  Min.   :-876.0   A:1365
##  1st Qu.: 370.8   B: 901
##  Median : 560.0   C: 112
##  Mean   : 475.2   D: 276
##  3rd Qu.: 670.0   E:1370
##  Max.   :1040.0
##
```

```
summary(data$classe)
```

```
##    A    B    C    D    E
## 1365  901  112  276 1370
```

```
names(data)
```

```
##   [1] "user_name"                "raw_timestamp_part_1"
##   [3] "raw_timestamp_part_2"     "cvtd_timestamp"
##   [5] "new_window"               "num_window"
##   [7] "roll_belt"                "pitch_belt"
##   [9] "yaw_belt"                 "total_accel_belt"
##  [11] "kurtosis_roll_belt"       "kurtosis_picth_belt"
##  [13] "skewness_roll_belt"       "skewness_roll_belt.1"
##  [15] "max_roll_belt"            "max_picth_belt"
##  [17] "max_yaw_belt"             "min_roll_belt"
##  [19] "min_pitch_belt"           "min_yaw_belt"
##  [21] "amplitude_roll_belt"      "amplitude_pitch_belt"
##  [23] "amplitude_yaw_belt"       "var_total_accel_belt"
##  [25] "avg_roll_belt"            "stddev_roll_belt"
##  [27] "var_roll_belt"            "avg_pitch_belt"
##  [29] "stddev_pitch_belt"        "var_pitch_belt"
##  [31] "avg_yaw_belt"             "stddev_yaw_belt"
##  [33] "var_yaw_belt"             "gyros_belt_x"
##  [35] "gyros_belt_y"             "gyros_belt_z"
##  [37] "accel_belt_x"             "accel_belt_y"
##  [39] "accel_belt_z"             "magnet_belt_x"
##  [41] "magnet_belt_y"            "magnet_belt_z"
##  [43] "roll_arm"                 "pitch_arm"
##  [45] "yaw_arm"                  "total_accel_arm"
##  [47] "var_accel_arm"            "avg_roll_arm"
##  [49] "stddev_roll_arm"          "var_roll_arm"
##  [51] "avg_pitch_arm"            "stddev_pitch_arm"
##  [53] "var_pitch_arm"            "avg_yaw_arm"
```

```
##  [55] "stddev_yaw_arm"           "var_yaw_arm"
##  [57] "gyros_arm_x"              "gyros_arm_y"
##  [59] "gyros_arm_z"              "accel_arm_x"
##  [61] "accel_arm_y"              "accel_arm_z"
##  [63] "magnet_arm_x"             "magnet_arm_y"
##  [65] "magnet_arm_z"             "kurtosis_roll_arm"
##  [67] "kurtosis_picth_arm"       "kurtosis_yaw_arm"
##  [69] "skewness_roll_arm"        "skewness_pitch_arm"
##  [71] "skewness_yaw_arm"         "max_roll_arm"
##  [73] "max_picth_arm"            "max_yaw_arm"
##  [75] "min_roll_arm"             "min_pitch_arm"
##  [77] "min_yaw_arm"              "amplitude_roll_arm"
##  [79] "amplitude_pitch_arm"      "amplitude_yaw_arm"
##  [81] "roll_dumbbell"            "pitch_dumbbell"
##  [83] "yaw_dumbbell"             "kurtosis_roll_dumbbell"
##  [85] "kurtosis_picth_dumbbell"  "kurtosis_yaw_dumbbell"
##  [87] "skewness_roll_dumbbell"   "skewness_pitch_dumbbell"
##  [89] "skewness_yaw_dumbbell"    "max_roll_dumbbell"
##  [91] "max_picth_dumbbell"       "max_yaw_dumbbell"
##  [93] "min_roll_dumbbell"        "min_pitch_dumbbell"
##  [95] "min_yaw_dumbbell"         "amplitude_roll_dumbbell"
##  [97] "amplitude_pitch_dumbbell" "amplitude_yaw_dumbbell"
##  [99] "total_accel_dumbbell"     "var_accel_dumbbell"
## [101] "avg_roll_dumbbell"        "stddev_roll_dumbbell"
## [103] "var_roll_dumbbell"        "avg_pitch_dumbbell"
## [105] "stddev_pitch_dumbbell"    "var_pitch_dumbbell"
## [107] "avg_yaw_dumbbell"         "stddev_yaw_dumbbell"
## [109] "var_yaw_dumbbell"         "gyros_dumbbell_x"
## [111] "gyros_dumbbell_y"         "gyros_dumbbell_z"
## [113] "accel_dumbbell_x"         "accel_dumbbell_y"
## [115] "accel_dumbbell_z"         "magnet_dumbbell_x"
## [117] "magnet_dumbbell_y"        "magnet_dumbbell_z"
## [119] "roll_forearm"             "pitch_forearm"
## [121] "yaw_forearm"              "kurtosis_roll_forearm"
## [123] "kurtosis_picth_forearm"   "kurtosis_yaw_forearm"
## [125] "skewness_roll_forearm"    "skewness_pitch_forearm"
## [127] "skewness_yaw_forearm"     "max_roll_forearm"
## [129] "max_picth_forearm"        "max_yaw_forearm"
## [131] "min_roll_forearm"         "min_pitch_forearm"
## [133] "min_yaw_forearm"          "amplitude_roll_forearm"
## [135] "amplitude_pitch_forearm"  "amplitude_yaw_forearm"
## [137] "total_accel_forearm"      "var_accel_forearm"
## [139] "avg_roll_forearm"         "stddev_roll_forearm"
## [141] "var_roll_forearm"         "avg_pitch_forearm"
## [143] "stddev_pitch_forearm"     "var_pitch_forearm"
## [145] "avg_yaw_forearm"          "stddev_yaw_forearm"
## [147] "var_yaw_forearm"          "gyros_forearm_x"
## [149] "gyros_forearm_y"          "gyros_forearm_z"
## [151] "accel_forearm_x"          "accel_forearm_y"
## [153] "accel_forearm_z"          "magnet_forearm_x"
```

```
## [155] "magnet_forearm_y"         "magnet_forearm_z"
## [157] "classe"
```

```
library(devtools)
install_github('adam-m-mcelhinney/helpRFunctions')
```

```
## Skipping install of 'helpRFunctions' from a github remote, the SHA1 (9eb16
e8c) has not changed since last install.
##   Use `force = TRUE` to force installation
```

```
library(helpRFunctions)
```

```
## Loading required package: caret
```

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

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

```
training<-data[1:4000,]
testing<-data[4001:4024,]
dim(training)
```

```
## [1] 4000  157
```

```
str(training)
```

```
## 'data.frame':    4000 obs. of  157 variables:
##  $ user_name               : Factor w/ 5 levels "adelmo","carlitos",..: 3
3 3 3 3 3 3 3 3 3 ...
##  $ raw_timestamp_part_1    : int  1322489729 1322489729 1322489729 1322489
729 1322489729 1322489729 1322489729 1322489729 1322489729 1322489729 ...
##  $ raw_timestamp_part_2    : int  34670 62641 70653 82654 90637 170626 190
665 242723 267551 274689 ...
##  $ cvtd_timestamp          : Factor w/ 7 levels "2/12/2011 13:35",..: 2 2
2 2 2 2 2 2 2 2 ...
##  $ new_window              : Factor w/ 2 levels "no","yes": 1 1 1 1 1 1 1
1 1 1 ...
##  $ num_window              : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ roll_belt               : num  3.7 3.66 3.58 3.56 3.57 3.45 3.31 2.91 2
.31 2 ...
##  $ pitch_belt              : num  41.6 42.8 43.7 44.4 45.1 45.6 46.2 46.9
47.4 47.7 ...
##  $ yaw_belt                : num  -82.8 -82.5 -82.3 -82.1 -81.9 -81.9 -81.
9 -82.2 -82.6 -82.8 ...
##  $ total_accel_belt        : int  3 2 1 1 1 1 3 4 2 3 ...
##  $ kurtosis_roll_belt      : num  -1.04 -1.04 -1.04 -1.04 -1.04 ...
##  $ kurtosis_picth_belt     : num  -0.391 -0.391 -0.391 -0.391 -0.391 ...
##  $ skewness_roll_belt      : num  0.00541 0.00541 0.00541 0.00541 0.00541
...
##  $ skewness_roll_belt.1    : num  0.0451 0.0451 0.0451 0.0451 0.0451 ...
##  $ max_roll_belt           : num  -4.1 -4.1 -4.1 -4.1 -4.1 -4.1 -4.1 -4.1
-4.1 -4.1 ...
```

```
##  $ max_picth_belt          : int  20 20 20 20 20 20 20 20 20 20 ...
##  $ max_yaw_belt            : num  -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 ...
##  $ min_roll_belt           : num  -7.25 -7.25 -7.25 -7.25 -7.25 -7.25 -7.2
5 -7.25 -7.25 -7.25 ...
##  $ min_pitch_belt          : int  18 18 18 18 18 18 18 18 18 18 ...
##  $ min_yaw_belt            : num  -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 ...
##  $ amplitude_roll_belt     : num  1.34 1.34 1.34 1.34 1.34 ...
##  $ amplitude_pitch_belt    : int  2 2 2 2 2 2 2 2 2 2 ...
##  $ amplitude_yaw_belt      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ var_total_accel_belt    : num  0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3
...
##  $ avg_roll_belt           : num  122 122 122 122 122 ...
##  $ stddev_roll_belt        : num  0.6 0.6 0.6 0.6 0.6 0.6 0.6 0.6 0.6 0.6
...
##  $ var_roll_belt           : num  0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35
0.35 0.35 ...
##  $ avg_pitch_belt          : num  25.8 25.8 25.8 25.8 25.8 ...
##  $ stddev_pitch_belt       : num  0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35
0.35 0.35 ...
##  $ var_pitch_belt          : num  0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1
...
##  $ avg_yaw_belt            : num  -4.95 -4.95 -4.95 -4.95 -4.95 -4.95 -4.9
5 -4.95 -4.95 -4.95 ...
##  $ stddev_yaw_belt         : num  0.4 0.4 0.4 0.4 0.4 0.4 0.4 0.4 0.4 0.4
...
##  $ var_yaw_belt            : num  0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17
0.17 0.17 ...
##  $ gyros_belt_x            : num  2.02 1.96 1.88 1.8 1.77 1.75 1.78 1.75 1
.65 1.48 ...
##  $ gyros_belt_y            : num  0.18 0.14 0.08 0.03 0 -0.03 -0.06 -0.06
-0.03 -0.06 ...
##  $ gyros_belt_z            : num  0.02 0.05 0.05 0.08 0.13 0.16 0.15 0.23
0.33 0.21 ...
##  $ accel_belt_x            : int  -3 -2 -2 -6 -4 1 1 2 -1 -18 ...
##  $ accel_belt_y            : int  -18 -13 -6 -5 -9 -9 -24 -36 -19 18 ...
##  $ accel_belt_z            : int  22 16 8 7 0 -5 -8 -9 -7 1 ...
##  $ magnet_belt_x           : int  387 405 409 422 418 432 438 440 443 449
...
##  $ magnet_belt_y           : int  525 512 511 513 508 510 508 503 507 499
...
##  $ magnet_belt_z           : int  -267 -254 -244 -221 -208 -189 -176 -163
-140 -132 ...
##  $ roll_arm                : num  132 129 125 120 115 110 104 98.6 93.2 88
.5 ...
##  $ pitch_arm               : num  -43.7 -45.3 -46.8 -48.1 -49.1 -49.6 -49.
9 -49.7 -49 -48.1 ...
##  $ yaw_arm                 : num  -53.6 -49 -43.7 -38.1 -31.7 -25.8 -18.5
-11.4 -4.49 1.82 ...
##  $ total_accel_arm         : int  38 38 35 35 34 33 29 28 27 22 ...
##  $ var_accel_arm           : num  65.1 65.1 65.1 65.1 65.1 ...
```

```
##  $ avg_roll_arm             : num  76.2 76.2 76.2 76.2 76.2 ...
##  $ stddev_roll_arm          : num  16.1 16.1 16.1 16.1 16.1 ...
##  $ var_roll_arm             : num  259 259 259 259 259 ...
##  $ avg_pitch_arm            : num  -10.2 -10.2 -10.2 -10.2 -10.2 ...
##  $ stddev_pitch_arm         : num  10.7 10.7 10.7 10.7 10.7 ...
##  $ var_pitch_arm            : num  114 114 114 114 114 ...
##  $ avg_yaw_arm              : num  19.1 19.1 19.1 19.1 19.1 ...
##  $ stddev_yaw_arm           : num  35.9 35.9 35.9 35.9 35.9 ...
##  $ var_yaw_arm              : num  1287 1287 1287 1287 1287 ...
##  $ gyros_arm_x              : num  2.65 2.79 2.91 3.08 3.2 3.31 3.5 3.53 3.
4 3.48 ...
##  $ gyros_arm_y              : num  -0.61 -0.64 -0.69 -0.72 -0.77 -0.83 -0.8
3 -0.83 -0.83 -0.8 ...
##  $ gyros_arm_z              : num  -0.02 -0.11 -0.15 -0.23 -0.25 -0.3 -0.31
-0.21 -0.11 -0.15 ...
##  $ accel_arm_x              : int  143 146 156 158 163 160 165 153 143 135
...
##  $ accel_arm_y              : int  30 35 44 52 55 59 67 70 78 96 ...
##  $ accel_arm_z              : int  -346 -339 -307 -305 -288 -274 -225 -218
-205 -134 ...
##  $ magnet_arm_x             : int  556 599 613 646 670 696 721 725 740 741
...
##  $ magnet_arm_y             : int  -205 -206 -198 -186 -175 -174 -161 -152
-133 -115 ...
##  $ magnet_arm_z             : int  -374 -335 -319 -268 -241 -193 -121 -105
-43 14 ...
##  $ kurtosis_roll_arm        : num  -1.18 -1.18 -1.18 -1.18 -1.18 ...
##  $ kurtosis_picth_arm       : num  -0.969 -0.969 -0.969 -0.969 -0.969 ...
##  $ kurtosis_yaw_arm         : num  -0.87 -0.87 -0.87 -0.87 -0.87 ...
##  $ skewness_roll_arm        : num  0.124 0.124 0.124 0.124 0.124 ...
##  $ skewness_pitch_arm       : num  -0.103 -0.103 -0.103 -0.103 -0.103 ...
##  $ skewness_yaw_arm         : num  0.0598 0.0598 0.0598 0.0598 0.0598 ...
##  $ max_roll_arm             : num  8.45 8.45 8.45 8.45 8.45 8.45 8.45 8.45
8.45 8.45 ...
##  $ max_picth_arm            : num  77.2 77.2 77.2 77.2 77.2 ...
##  $ max_yaw_arm              : int  38 38 38 38 38 38 38 38 38 38 ...
##  $ min_roll_arm             : num  -33.6 -33.6 -33.6 -33.6 -33.6 -33.6 -33.
6 -33.6 -33.6 -33.6 ...
##  $ min_pitch_arm            : num  -58.6 -58.6 -58.6 -58.6 -58.6 -58.6 -58.
6 -58.6 -58.6 -58.6 ...
##  $ min_yaw_arm              : int  10 10 10 10 10 10 10 10 10 10 ...
##  $ amplitude_roll_arm       : num  36.9 36.9 36.9 36.9 36.9 ...
##  $ amplitude_pitch_arm      : num  122 122 122 122 122 ...
##  $ amplitude_yaw_arm        : int  27 27 27 27 27 27 27 27 27 27 ...
##  $ roll_dumbbell            : num  51.2 55.8 55.5 55.9 55.2 ...
##  $ pitch_dumbbell           : num  11.7 9.65 6.88 11.08 11.43 ...
##  $ yaw_dumbbell             : num  104.3 100.2 101.1 99.8 100.4 ...
##  $ kurtosis_roll_dumbbell   : num  -0.0959 -0.0959 -0.0959 -0.0959 -0.0959
...
##  $ kurtosis_picth_dumbbell : num  -0.442 -0.442 -0.442 -0.442 -0.442 ...
```

```
##  $ kurtosis_yaw_dumbbell   : logi  NA NA NA NA NA NA ...
##  $ skewness_roll_dumbbell  : num  0.0819 0.0819 0.0819 0.0819 0.0819 0.081
9 0.0819 0.0819 0.0819 0.0819 ...
##  $ skewness_pitch_dumbbell : num  -0.216 -0.216 -0.216 -0.216 -0.216 -0.21
6 -0.216 -0.216 -0.216 -0.216 ...
##  $ skewness_yaw_dumbbell   : logi  NA NA NA NA NA NA ...
##  $ max_roll_dumbbell       : num  41.9 41.9 41.9 41.9 41.9 ...
##  $ max_picth_dumbbell      : num  133 133 133 133 133 133 133 133 133 133
...
##  $ max_yaw_dumbbell        : num  -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1
-0.1 -0.1 ...
##  $ min_roll_dumbbell       : num  -26.8 -26.8 -26.8 -26.8 -26.8 ...
##  $ min_pitch_dumbbell      : num  20.2 20.2 20.2 20.2 20.2 20.2 20.2 20.2
20.2 20.2 ...
##  $ min_yaw_dumbbell        : num  -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1
-0.1 -0.1 ...
##  $ amplitude_roll_dumbbell : num  55.7 55.7 55.7 55.7 55.7 ...
##  $ amplitude_pitch_dumbbell: num  54.7 54.7 54.7 54.7 54.7 ...
##  $ amplitude_yaw_dumbbell  : int  NA NA NA NA NA NA NA NA NA NA ...
##  $ total_accel_dumbbell    : int  4 4 4 5 4 4 4 4 4 4 ...
##   [list output truncated]
```

```
summary(training)
```

```
##    user_name    raw_timestamp_part_1  raw_timestamp_part_2
## adelmo : 311 Min. :1.322e+09 Min. :  297
##  carlitos:1580   1st Qu.:1.323e+09   1st Qu.:240437
##   eurico  :  88  Median :1.323e+09   Median :492290
##  jeremy  :   4   Mean   :1.323e+09   Mean   :489477
##  pedro   :2017   3rd Qu.:1.323e+09   3rd Qu.:734821
##                  Max.   :1.323e+09   Max.   :996453
##
##           cvtd_timestamp new_window   num_window      roll_belt
##  2/12/2011 13:35 : 311   no :3913   Min.   : 1.00   Min.   :-28.90
##  28/11/2011 14:15:  88   yes:  87   1st Qu.:24.00   1st Qu.:  1.35
##  30/11/2011 17:12:   4              Median :46.00   Median :122.00
##  5/12/2011 11:23 : 337              Mean   :46.06   Mean   : 73.02
##  5/12/2011 11:25 :1243              3rd Qu.:68.00   3rd Qu.:124.00
##  5/12/2011 14:22 : 456              Max.   :91.00   Max.   :159.00
##  5/12/2011 14:23 :1561
##    pitch_belt        yaw_belt       total_accel_belt kurtosis_roll_belt
##  Min.   :-56.20   Min.   :-179.00   Min.   : 0.00    Min.   :-3.333
##  1st Qu.:  6.20   1st Qu.: -93.10   1st Qu.: 3.00    1st Qu.:-1.036
##  Median : 25.50   Median :  -5.02   Median :19.00    Median :-1.036
## Mean : 14.09 Mean : -31.14 Mean :12.73 Mean  :-1.027
##  3rd Qu.: 26.40  3rd Qu.:  -2.67   3rd Qu.:20.00    3rd Qu.:-1.036
##  Max.  : 60.30   Max.   : 179.00   Max.   :26.00    Max.   : 7.515
##
## kurtosis_picth_belt skewness_roll_belt  skewness_roll_belt.1
## Min. :-2.1212 Min. :-3.031527 Min.  :-6.63325
```

```
##  1st Qu.:-0.3913     1st Qu.: 0.005406   1st Qu.: 0.04512
##  Median :-0.3913     Median : 0.005406   Median : 0.04512
##  Mean   :-0.3497     Mean   : 0.003849   Mean   : 0.03965
##  3rd Qu.:-0.3913     3rd Qu.: 0.005406   3rd Qu.: 0.04512
##  Max.   :54.0000     Max.   : 2.713152   Max.   : 7.34847
##
##  max_roll_belt     max_picth_belt   max_yaw_belt     min_roll_belt
##  Min.   :-94.400   Min.   : 3.00   Min.   :-3.3000   Min.   :-179.000
##  1st Qu.: -4.100   1st Qu.:20.00   1st Qu.:-1.0000   1st Qu.:  -7.250
##  Median : -4.100   Median :20.00   Median :-1.0000   Median :  -7.250
##  Mean   : -4.629   Mean   :19.87   Mean   :-0.9917   Mean   :  -7.842
##  3rd Qu.: -4.100   3rd Qu.:20.00   3rd Qu.:-1.0000   3rd Qu.:  -7.250
##  Max.   :179.000   Max.   :26.00   Max.   : 7.5000   Max.   : 157.000
##
##  min_pitch_belt   min_yaw_belt     amplitude_roll_belt
##  Min.   : 0.00   Min.   :-3.3000   Min.   :  0.000
##  1st Qu.:18.00   1st Qu.:-1.0000   1st Qu.:  1.345
##  Median :18.00   Median :-1.0000   Median :  1.345
##  Mean  :17.86   Mean   :-0.9917   Mean   :  1.447
##  3rd Qu.:18.00   3rd Qu.:-1.0000   3rd Qu.:  1.345
##  Max.  :20.00   Max.   : 7.5000   Max.   :358.000
##
## amplitude_pitch_belt amplitude_yaw_belt var_total_accel_belt
##  Min.   : 0.000       Min.    0          Min.   : 0.000
##  1st Qu.: 2.000       1st Qu.:0          1st Qu.: 0.300
##  Median : 2.000       Median :0          Median : 0.300
##  Mean   : 2.014       Mean    0          Mean   : 0.315
##  3rd Qu.: 2.000       3rd Qu.:0          3rd Qu.: 0.300
##  Max.   :21.000       Max.    0          Max.   :18.200
##
##  avg_roll_belt   stddev_roll_belt var_roll_belt     avg_pitch_belt
##  Min.   :-27.4   Min.   :0.0000   Min.   : 0.0000   Min.   :-49.40
##  1st Qu.:121.9   1st Qu.:0.6000   1st Qu.: 0.3500   1st Qu.: 25.75
##  Median :121.9   Median :0.6000   Median : 0.3500   Median : 25.75
##  Mean   :120.8   Mean   :0.6259   Mean   : 0.5383   Mean   : 25.49
##  3rd Qu.:121.9   3rd Qu.:0.6000   3rd Qu.: 0.3500   3rd Qu.: 25.75
##  Max.   :154.5   Max.   :8.5000   Max.   :71.8000   Max.   : 59.70
##
##  stddev_pitch_belt var_pitch_belt    avg_yaw_belt     stddev_yaw_belt
##  Min.   :0.0000    Min.   : 0.000   Min.   :-94.400   Min.   :  0.0000
##  1st Qu.:0.3500    1st Qu.: 0.100   1st Qu.: -4.950   1st Qu.:  0.4000
##  Median :0.3500    Median : 0.100   Median : -4.950   Median :  0.4000
##  Mean   :0.3574    Mean   : 0.129   Mean   : -5.518   Mean   :  0.4452
##  3rd Qu.:0.3500    3rd Qu.: 0.100   3rd Qu.: -4.950   3rd Qu.:  0.4000
##  Max.   :6.2000    Max.   :39.000   Max.   :158.600   Max.   :163.1000
##
##   var_yaw_belt        gyros_belt_x     gyros_belt_y      gyros_belt_z
##  Min.   :    0.000   Min.   :-0.790   Min.   :-0.4700   Min.   :-0.7700
##  1st Qu.:    0.170   1st Qu.:-0.430   1st Qu.:-0.0300   1st Qu.:-0.4600
##  Median :    0.170   Median :-0.240   Median :-0.0200   Median :-0.4100
```

```
##  Mean   :   6.836   Mean   :-0.181   Mean   :-0.0087   Mean   :-0.2452
##  3rd Qu.:  0.170   3rd Qu.: 0.020   3rd Qu.: 0.0000   3rd Qu.:-0.0200
##  Max.   :26610.320  Max.   : 2.020   Max.   : 0.4200   Max.   : 0.8200
##
##   accel_belt_x      accel_belt_y     accel_belt_z     magnet_belt_x
##  Min.   :-120.00   Min.   :-71.00   Min.   :-244.00   Min.   :-30.00
##  1st Qu.: -42.00   1st Qu.:  4.00   1st Qu.:-176.00   1st Qu.: -3.00
##  Median : -33.00   Median : 65.00   Median :-165.50   Median :  2.00
##  Mean   : -24.27   Mean   : 39.66   Mean   : -94.28   Mean   : 24.81
##  3rd Qu.: -16.00   3rd Qu.: 70.00   3rd Qu.:  20.00   3rd Qu.:  9.00
##  Max.   :  80.00   Max.   :164.00   Max.   :  77.00   Max.   :485.00
##
##  magnet_belt_y   magnet_belt_z       roll_arm         pitch_arm
##  Min.   :428.0   Min.   :-513.0   Min.   :-180.00   Min.   :-87.100
##  1st Qu.:577.0   1st Qu.:-380.0   1st Qu.: -34.85   1st Qu.:-32.300
##  Median :585.0   Median :-366.0   Median :  71.95   Median : -8.815
##  Mean   :582.6   Mean   :-340.7   Mean   :  39.79   Mean   :-10.700
##  3rd Qu.:601.0   3rd Qu.:-311.0   3rd Qu.: 124.00   3rd Qu.: 14.500
##  Max.   :652.0   Max.   : 293.0   Max.   : 180.00   Max.   : 81.400
##
##     yaw_arm         total_accel_arm var_accel_arm     avg_roll_arm
##  Min.   :-180.000   Min.   : 1.00   Min.   :  0.00   Min.   :-169.69
##  1st Qu.: -60.125   1st Qu.:15.00   1st Qu.: 65.10   1st Qu.:  76.22
##  Median :  16.900   Median :25.00   Median : 65.10   Median :  76.22
##  Mean   :  2.597   Mean   :24.86   Mean   : 65.28   Mean   :  75.36
##  3rd Qu.:  73.300   3rd Qu.:34.00   3rd Qu.: 65.10   3rd Qu.:  76.22
##  Max.   : 180.000   Max.   :59.00   Max.   :253.01   Max.   : 160.78
##
##  stddev_roll_arm   var_roll_arm     avg_pitch_arm    stddev_pitch_arm
##  Min.   :  0.00   Min.   :    0.0   Min.   :-57.29   Min.   : 0.00
##  1st Qu.: 16.10   1st Qu.:  259.4   1st Qu.:-10.17   1st Qu.:10.67
##  Median : 16.10   Median :  259.4   Median :-10.17   Median :10.67
##  Mean   : 16.23   Mean   :  283.7   Mean   :-10.16   Mean   :10.70
##  3rd Qu.: 16.10   3rd Qu.:  259.4   3rd Qu.:-10.17   3rd Qu.:10.67
##  Max.   :161.96   Max.   :26232.2   Max.   : 54.60   Max.   :30.78
##
##   var_pitch_arm     avg_yaw_arm     stddev_yaw_arm     var_yaw_arm
##  Min.   :  0.0   Min.   :-164.64   Min.   :  0.00   Min.   :    0
##  1st Qu.:113.8   1st Qu.:  19.06   1st Qu.: 35.88   1st Qu.: 1287
##  Median :113.8   Median :  19.06   Median : 35.88   Median : 1287
##  Mean   :116.2   Mean   :  18.69   Mean   : 35.90   Mean   : 1307
##  3rd Qu.:113.8   3rd Qu.:  19.06   3rd Qu.: 35.88   3rd Qu.: 1287
##  Max.   :947.3   Max.   : 148.45   Max.   :177.04   Max.    31345
##
##   gyros_arm_x       gyros_arm_y       gyros_arm_z        accel_arm_x
##  Min.   :-5.2000   Min.   :-3.4400   Min.   :-2.17000   Min.   :-346.00
##  1st Qu.:-2.0925   1st Qu.:-0.9300   1st Qu.:-0.20000   1st Qu.: -89.00
##  Median :-0.0200   Median :-0.0300   Median : 0.00000   Median :  23.00
##  Mean   :-0.1771   Mean   :-0.1846   Mean   : 0.04549   Mean   :  33.03
##  3rd Qu.: 1.7200   3rd Qu.: 0.5800   3rd Qu.: 0.28000   3rd Qu.: 134.25
```

```
##  Max.   : 4.3400   Max.   : 2.4600   Max.   : 3.02000   Max.   : 434.00
##
##   accel_arm_y       accel_arm_z       magnet_arm_x     magnet_arm_y
##  Min.   :-252.00   Min.   :-538.00   Min.   :-515.0   Min.   :-392.0
##  1st Qu.: -21.00   1st Qu.:-124.00   1st Qu.:-335.2   1st Qu.: -14.0
##  Median :  22.00   Median :   5.00   Median : 273.5   Median : 269.0
##  Mean   :  27.02   Mean   : -42.21   Mean   : 192.5   Mean   : 161.4
##  3rd Qu.:  98.00   3rd Qu.:  75.00   3rd Qu.: 653.0   3rd Qu.: 348.0
##  Max.   : 229.00   Max.   : 209.00   Max.   : 782.0   Max.   : 482.0
##
##   magnet_arm_z    kurtosis_roll_arm kurtosis_picth_arm kurtosis_yaw_arm
##  Min.   :-573.0   Min.   :-3.333    Min.   :-2.0835    Min.   :-1.6308
##  1st Qu.:  -3.0   1st Qu.:-1.182    1st Qu.:-0.9691    1st Qu.:-0.8698
##  Median : 432.0   Median :-1.182    Median :-0.9691    Median :-0.8698
##  Mean   : 252.3   Mean   :-1.172    Mean   :-0.9504    Mean   :-0.8478
##  3rd Qu.: 515.0   3rd Qu.:-1.182    3rd Qu.:-0.9691    3rd Qu.:-0.8698
##  Max.   : 647.0   Max.   :18.719    Max.   :23.8408    Max.   :36.0000
##
##  skewness_roll_arm skewness_pitch_arm skewness_yaw_arm    max_roll_arm
##  Min.   :-1.7457   Min.   :-4.9942    Min.   :-6.00000   Min.   :-36.300
##  1st Qu.: 0.1235   1st Qu.:-0.1032    1st Qu.: 0.05976   1st Qu.:  8.450
##  Median : 0.1235   Median :-0.1032    Median : 0.05976   Median :  8.450
##  Mean   : 0.1247   Mean   :-0.1059    Mean   : 0.05745   Mean   :  8.472
##  3rd Qu.: 0.1235   3rd Qu.:-0.1032    3rd Qu.: 0.05976   3rd Qu.:  8.450
##  Max.   : 4.3945   Max.   : 2.1711    Max.   : 2.10699   Max.   : 81.400
##
##  max_picth_arm      max_yaw_arm  min_roll_arm    min_pitch_arm
##  Min.   :-164.00   Min.   : 3   Min.   :-87.10   Min.   :-180.00
##  1st Qu.:  77.25   1st Qu.:38   1st Qu.:-33.60   1st Qu.: -58.60
##  Median :  77.25   Median :38   Median :-33.60   Median : -58.60
##  Mean   :  76.78   Mean   :38   Mean   :-33.48   Mean   : -58.55
##  3rd Qu.:  77.25   3rd Qu.:38   3rd Qu.:-33.60   3rd Qu.: -58.60
##  Max.   : 180.00   Max.   :59   Max.   : 35.70   Max.   : 146.00
##
##   min_yaw_arm    amplitude_roll_arm amplitude_pitch_arm amplitude_yaw_arm
##  Min.   : 1.00   Min.   : 0.00      Min.   :  0.0       Min.   : 0.00
##  1st Qu.:10.00   1st Qu.:36.95      1st Qu.:121.5       1st Qu.:27.00
##  Median :10.00   Median :36.95      Median :121.5       Median :27.00
##  Mean   :10.06   Mean   :36.96      Mean   :121.3       Mean   :26.96
##  3rd Qu.:10.00   3rd Qu.:36.95      3rd Qu.:121.5       3rd Qu.:27.00
##  Max.   :34.00   Max.   :90.00      Max.   :360.0       Max.   :52.00
##
##  roll_dumbbell       pitch_dumbbell       yaw_dumbbell
## Min. :-152.782 Min. :-134.732 Min.  :-129.33
##  1st Qu.: -34.555   1st Qu.: -13.297   1st Qu.:  21.09
##  Median :  -1.805   Median :  14.481   Median :  71.38
##  Mean   :   3.693   Mean   :   5.088   Mean   :  55.31
##  3rd Qu.:  58.532   3rd Qu.:  27.950   3rd Qu.: 121.91
##  Max.   : 139.729   Max.   :  97.281   Max.   : 152.92
##
```

```
##  kurtosis_roll_dumbbell kurtosis_picth_dumbbell kurtosis_yaw_dumbbell
##  Min.   :-2.08890       Min.   :-2.0889         Mode:logical
##  1st Qu.:-0.09595       1st Qu.:-0.4422         NA's:4000
##  Median :-0.09595       Median :-0.4422
##   Mean   :-0.08657      Mean   :-0.4310
##   3rd Qu.:-0.09595      3rd Qu.:-0.4422
##   Max.   : 7.56330      Max.   :11.2734
##
##  skewness_roll_dumbbell skewness_pitch_dumbbell skewness_yaw_dumbbell
##  Min.   :-2.61100       Min.   :-2.0501         Mode:logical
##  1st Qu.: 0.08190       1st Qu.:-0.2160         NA's:4000
##  Median : 0.08190       Median :-0.2160
##   Mean   : 0.08055      Mean   :-0.2132
##   3rd Qu.: 0.08190      3rd Qu.:-0.2160
##   Max.   : 2.38140      Max.   : 2.7832
##
##  max_roll_dumbbell max_picth_dumbbell max_yaw_dumbbell   min_roll_dumbbell
##  Min.   :-70.90    Min.   :-84.5      Min.   :-2.10000   Min.   :-134.70
##  1st Qu.: 41.85    1st Qu.:133.0      1st Qu.:-0.10000   1st Qu.: -26.75
##  Median : 41.85    Median :133.0      Median :-0.10000   Median : -26.75
##   Mean   : 41.68    Mean   :132.0     Mean   :-0.09047   Mean   : -26.76
##   3rd Qu.: 41.85    3rd Qu.:133.0     3rd Qu.:-0.10000   3rd Qu.: -26.75
##   Max.   : 97.30    Max.   :152.9     Max.   : 7.60000   Max.   :  26.80
##
##  min_pitch_dumbbell min_yaw_dumbbell   amplitude_roll_dumbbell
##  Min.   :-129.30    Min.   :-2.10000   Min.   :  0.00
##  1st Qu.:  20.20    1st Qu.:-0.10000   1st Qu.: 55.71
##  Median :  20.20    Median :-0.10000   Median : 55.71
##   Mean   :  20.09   Mean   :-0.09047   Mean   : 55.83
##   3rd Qu.:  20.20   3rd Qu.:-0.10000   3rd Qu.: 55.71
##   Max.   : 122.90   Max.   : 7.60000   Max.   :171.75
##
##  amplitude_pitch_dumbbell amplitude_yaw_dumbbell total_accel_dumbbell
##  Min.   :  0.00           Min.   :0              Min.   : 1.00
##  1st Qu.: 54.74           1st Qu.:0              1st Qu.: 6.00
##  Median : 54.74           Median :0              Median : 9.00
##  Mean   : 55.12           Mean   :0              Mean   :12.04
##  3rd Qu.: 54.74           3rd Qu.:0              3rd Qu.:14.00
##  Max.   :217.33           Max.   :0              Max.   :37.00
##                           NA's   3913
##  var_accel_dumbbell avg_roll_dumbbell  stddev_roll_dumbbell
##  Min.   :  0.000    Min.   :-110.933   Min.   :  0.00
##  1st Qu.:  2.416    1st Qu.:  -5.118   1st Qu.: 17.06
##   Median :  2.416   Median :  -5.118   Median : 17.06
##   Mean   :  2.570   Mean   :  -4.934   Mean   : 17.26
##   3rd Qu.:  2.416   3rd Qu.:  -5.118   3rd Qu.: 17.06
##   Max.   :230.428   Max.   : 117.404   Max.   :103.12
##
## var_roll_dumbbell avg_pitch_dumbbell stddev_pitch_dumbbell
## Min. : 0.0 Min. :-70.92 Min. : 0.00
```

```
##  1st Qu.:  291.0   1st Qu.: 13.93     1st Qu.:14.11
##  Median :  291.0   Median : 13.93     Median :14.11
##  Mean   :  314.2   Mean   : 13.70     Mean   :14.13
##  3rd Qu.:  291.0   3rd Qu.: 13.93     3rd Qu.:14.11
##  Max.   :10634.5   Max.   : 57.45     Max.   :48.43
##
##  var_pitch_dumbbell avg_yaw_dumbbell  stddev_yaw_dumbbell var_yaw_dumbbell
##  Min.   :   0.0     Min.   :-105.65   Min.   : 0.00       Min.   :   0.0
##  1st Qu.: 199.1     1st Qu.:  64.71   1st Qu.:13.57       1st Qu.: 184.6
##  Median : 199.1     Median :  64.71   Median :13.57       Median : 184.6
##  Mean   : 202.1     Mean   :  64.40   Mean   :13.69       Mean   : 193.0
##  3rd Qu.: 199.1     3rd Qu.:  64.71   3rd Qu.:13.57       3rd Qu.: 184.6
##  Max.   :2345.4     Max.   : 129.93   Max.   :71.06       Max.   :5049.5
##
## gyros_dumbbell_x  gyros_dumbbell_y   gyros_dumbbell_z   accel_dumbbell_x
##  Min.  :-1.430  Min.   :-2.04000   Min.   :-1.4600   Min.   :-237.000
##  1st Qu.:-0.020   1st Qu.:-0.27000   1st Qu.:-0.3300   1st Qu.:  -6.000
##  Median : 0.320   Median :-0.06000   Median :-0.1300   Median :  11.000
##  Mean   : 0.248   Mean   :-0.04506   Mean   :-0.1345   Mean   :  -7.231
##  3rd Qu.: 0.530   3rd Qu.: 0.14000   3rd Qu.: 0.0300   3rd Qu.:  23.000
##  Max.   : 1.480   Max.   : 4.37000   Max.   : 1.8900   Max.   : 217.000
##
##  accel_dumbbell_y  accel_dumbbell_z  magnet_dumbbell_x  magnet_dumbbell_y
##  Min.   :-163.00   Min.   :-273.00   Min.   :-638.000   Min.   :-730.0
##  1st Qu.: -28.00   1st Qu.:  12.00   1st Qu.:-516.000   1st Qu.:-544.0
##  Median :  -1.00   Median :  50.00   Median : 103.500   Median :-480.0
##  Mean   :  13.06   Mean   :  16.28   Mean   :   7.495   Mean   :-113.2
##  3rd Qu.:  47.00   3rd Qu.:  79.00   3rd Qu.: 505.000   3rd Qu.: 305.0
##  Max.   : 281.00   Max.   : 122.00   Max.   : 579.000   Max.   : 618.0
##
##  magnet_dumbbell_z  roll_forearm     pitch_forearm     yaw_forearm
##  Min.   :-262.00   Min.   :-180.00   Min.   :-64.00   Min.   :-180.0
##  1st Qu.:-100.00   1st Qu.:-118.00   1st Qu.:  0.00   1st Qu.:-106.0
##  Median : -58.00   Median :  89.40   Median : 19.70   Median :  83.2
##  Mean   : -40.76   Mean   :  35.47   Mean   : 18.53   Mean   :  17.2
##  3rd Qu.:   2.00   3rd Qu.: 135.00   3rd Qu.: 43.90   3rd Qu.: 107.2
##  Max.   : 300.00   Max.   : 180.00   Max.   : 86.90   Max.   : 180.0
##
##  kurtosis_roll_forearm kurtosis_picth_forearm kurtosis_yaw_forearm
##  Min.   :-1.796        Min.   :-6.0000        Mode:logical
##  1st Qu.:-1.095        1st Qu.:-0.9752        NA's:4000
##  Median :-1.095        Median :-0.9752
##  Mean   :-1.088        Mean   :-0.9465
##  3rd Qu.:-1.095        3rd Qu.:-0.9752
##  Max.   : 6.651        Max.   :28.5654
##
##  skewness_roll_forearm skewness_pitch_forearm skewness_yaw_forearm
##  Min.   :-1.71990      Min.   :-4.5751        Mode:logical
##  1st Qu.:-0.05065      1st Qu.: 0.1729        NA's:4000
##  Median :-0.05065      Median : 0.1729
```

```
##  Mean    :-0.04779     Mean    : 0.1687
##  3rd Qu.:-0.05065     3rd Qu.: 0.1729
##  Max.    : 2.23660     Max.    : 3.5998
##
##  max_roll_forearm max_picth_forearm max_yaw_forearm  min_roll_forearm
##  Min.   :-63.90   Min.   :-152.0    Min.   :-1.800   Min.   :-64.000
##  1st Qu.: 49.60   1st Qu.: 168.0    1st Qu.:-1.100   1st Qu.:  4.650
##  Median : 49.60   Median : 168.0    Median :-1.100   Median :  4.650
##  Mean   : 49.25   Mean   : 166.8    Mean   :-1.093   Mean   :  4.614
##  3rd Qu.: 49.60   3rd Qu.: 168.0    3rd Qu.:-1.100   3rd Qu.:  4.650
##  Max.   : 86.90   Max.   : 180.0    Max.   : 6.700   Max.   : 47.500
##
##  min_pitch_forearm min_yaw_forearm  amplitude_roll_forearm
##  Min.   :-180.0    Min.   :-1.800   Min.   : 0.00
##  1st Qu.:-168.5    1st Qu.:-1.100   1st Qu.:32.20
##  Median :-168.5    Median :-1.100   Median :32.20
##  Mean   :-166.6    Mean   :-1.093   Mean   :32.16
##  3rd Qu.:-168.5    3rd Qu.:-1.100   3rd Qu.:32.20
##  Max.   : 125.0    Max.   : 6.700   Max.   :77.10
##
##  amplitude_pitch_forearm amplitude_yaw_forearm total_accel_forearm
##  Min.   :  0.0           Min.   :0             Min.   :11.00
##  1st Qu.:341.5           1st Qu.:0             1st Qu.:30.00
##  Median :341.5           Median :0             Median :35.00
##  Mean   :338.2           Mean   :0             Mean   :34.37
##  3rd Qu.:341.5           3rd Qu.:0             3rd Qu.:37.00
##  Max.   :359.0           Max.   :0             Max.   :59.00
##                          NA's    3921
##  var_accel_forearm avg_roll_forearm  stddev_roll_forearm var_roll_forearm
##  Min.   :  0.00    Min.   :-145.14   Min.   :  0.00      Min.   :    0
##  1st Qu.: 14.08    1st Qu.:  27.86   1st Qu.: 45.16      1st Qu.: 2749
##  Median : 14.08    Median :  27.86   Median : 45.16      Median : 2749
##  Mean   : 14.40    Mean   :  28.12   Mean   : 45.64      Mean   : 2886
##  3rd Qu.: 14.08    3rd Qu.:  27.86   3rd Qu.: 45.16      3rd Qu.: 2749
##  Max.   :109.09    Max.   : 151.25   Max.   :176.48      Max.    31145
##
##  avg_pitch_forearm stddev_pitch_forearm var_pitch_forearm
##  Min.   :-63.90    Min.   : 0.000       Min.   :  0.00
##  1st Qu.: 25.36    1st Qu.: 8.907       1st Qu.: 79.33
##  Median : 25.36    Median : 8.907       Median : 79.33
##  Mean   : 25.18    Mean   : 8.919       Mean   : 80.93
##  3rd Qu.: 25.36    3rd Qu.: 8.907       3rd Qu.: 79.33
##  Max.   : 68.17    Max.   :26.729       Max.   :714.45
##
## avg_yaw_forearm stddev_yaw_forearm var_yaw_forearm gyros_forearm_x
##  Min.   :-152.33   Min.   :  0.00     Min.   :    0   Min.   :-1.880
##  1st Qu.:  17.10   1st Qu.: 74.28     1st Qu.: 5542   1st Qu.:-0.140
##  Median :  17.10   Median : 74.28     Median : 5542   Median : 0.060
##  Mean   :  17.14   Mean   : 73.99     Mean   : 5576   Mean   : 0.111
##  3rd Qu.:  17.10   3rd Qu.: 74.28     3rd Qu.: 5542   3rd Qu.: 0.420
```

```
##  Max.   : 132.59   Max.   :197.51     Max.   :39009   Max.   : 1.810
##
##  gyros_forearm_y    gyros_forearm_z    accel_forearm_x    accel_forearm_y
##  Min.   :-5.73000   Min.   :-2.58000   Min.   :-328.000   Min.   :-467.0
##  1st Qu.:-1.81000   1st Qu.:-0.31000   1st Qu.:-117.000   1st Qu.:  71.0
##  Median :-0.02000   Median :-0.02000   Median :  -7.000   Median : 229.0
##  Mean   :-0.02303   Mean   : 0.08389   Mean   :  -6.931   Mean   : 170.6
##  3rd Qu.: 1.78000   3rd Qu.: 0.46000   3rd Qu.: 112.000   3rd Qu.: 296.0
##  Max.   : 5.17000   Max.   : 2.95000   Max.   : 279.000   Max.   : 575.0
##
##  accel_forearm_z  magnet_forearm_x  magnet_forearm_y magnet_forearm_z
##  Min.   :-366.0   Min.   :-1160.0   Min.   :-725.0   Min.   :-876.0
##  1st Qu.:-210.0   1st Qu.: -587.2   1st Qu.: -79.5   1st Qu.: 368.0
##  Median :-181.0   Median : -329.0   Median : 653.0   Median : 558.5
##  Mean   :-163.2   Mean   : -347.8   Mean   : 357.0   Mean   : 472.8
##  3rd Qu.:-150.0   3rd Qu.: -151.0   3rd Qu.: 747.0   3rd Qu.: 668.0
##  Max.   : 239.0   Max.   :  413.0   Max.   :1440.0   Max.   :1040.0
##
##  classe
##  A:1365
##  B: 901
##  C:  88
##  D:  276
##  E:1370
##
##
```

```
dim(training)
```

```
## [1] 4000  157
```

```
str(training$classe)
```

```
##  Factor w/ 5 levels "A","B","C","D",..: 5 5 5 5 5 5 5 5 5 5 ...
```

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

```
##    A    B    C    D    E
## 1365  901   88  276 1370
```

```
names(testing)[names(testing) != names(training)]
```

```
## character(0)
```

```
sum(is.na(training))
```

```
## [1] 23834
```

```
sum(is.na(testing))
```

```
## [1] 142
```

```
names(training)
```

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

```
## [101] "avg_roll_dumbbell"         "stddev_roll_dumbbell"
## [103] "var_roll_dumbbell"         "avg_pitch_dumbbell"
## [105] "stddev_pitch_dumbbell"     "var_pitch_dumbbell"
## [107] "avg_yaw_dumbbell"          "stddev_yaw_dumbbell"
## [109] "var_yaw_dumbbell"          "gyros_dumbbell_x"
## [111] "gyros_dumbbell_y"          "gyros_dumbbell_z"
## [113] "accel_dumbbell_x"          "accel_dumbbell_y"
## [115] "accel_dumbbell_z"          "magnet_dumbbell_x"
## [117] "magnet_dumbbell_y"         "magnet_dumbbell_z"
## [119] "roll_forearm"              "pitch_forearm"
## [121] "yaw_forearm"               "kurtosis_roll_forearm"
## [123] "kurtosis_picth_forearm"    "kurtosis_yaw_forearm"
## [125] "skewness_roll_forearm"     "skewness_pitch_forearm"
## [127] "skewness_yaw_forearm"      "max_roll_forearm"
## [129] "max_picth_forearm"         "max_yaw_forearm"
## [131] "min_roll_forearm"          "min_pitch_forearm"
## [133] "min_yaw_forearm"           "amplitude_roll_forearm"
## [135] "amplitude_pitch_forearm"   "amplitude_yaw_forearm"
## [137] "total_accel_forearm"       "var_accel_forearm"
## [139] "avg_roll_forearm"          "stddev_roll_forearm"
## [141] "var_roll_forearm"          "avg_pitch_forearm"
## [143] "stddev_pitch_forearm"      "var_pitch_forearm"
## [145] "avg_yaw_forearm"           "stddev_yaw_forearm"
## [147] "var_yaw_forearm"           "gyros_forearm_x"
## [149] "gyros_forearm_y"           "gyros_forearm_z"
## [151] "accel_forearm_x"           "accel_forearm_y"
## [153] "accel_forearm_z"           "magnet_forearm_x"
## [155] "magnet_forearm_y"          "magnet_forearm_z"
## [157] "classe"
```

```
predictorIdx <- c(grep("^accel", names(training)), grep("^gyros", names(train
ing)),
                  grep("^magnet", names(training)), grep("^roll", names(train
ing)), grep("^pitch", names(training)), grep("^yaw", names(training)), grep(
"^total", names(training)))

trainPredSet <- training[, c(predictorIdx, 157)]

testPredSet <- testing[, c(predictorIdx, 157)]
length(predictorIdx)
```

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

```
sum(names(testing)[predictorIdx] != names(training)[predictorIdx])
```

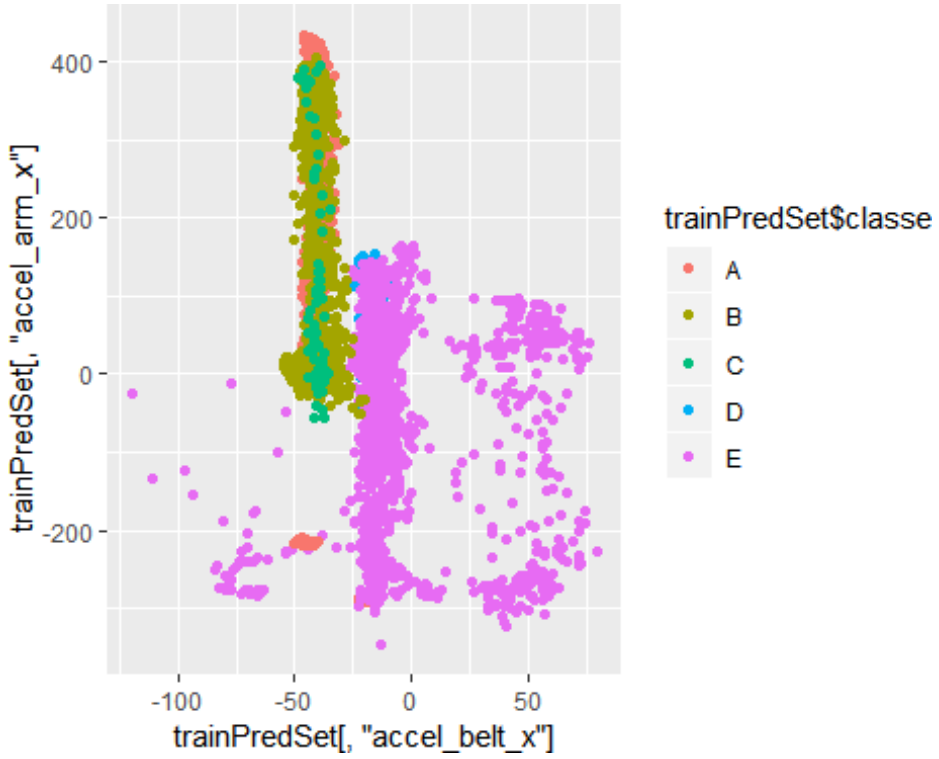
```
## [1] 0
```

```
#sum(is.na(trainPredSet)) color = trainPredSet$classe)
nearZeroVar(trainPredSet[, -7], saveMetric = TRUE)
```

```
##                      freqRatio percentUnique zeroVar   nzv
## accel_belt_x          1.027132         3.825   FALSE FALSE
## accel_belt_y          1.224784         2.800   FALSE FALSE
## accel_belt_z          1.049645         5.325   FALSE FALSE
## accel_arm_x           1.282353        17.650   FALSE FALSE
## accel_arm_y           1.129630        10.450   FALSE FALSE
## accel_arm_z           1.126582        16.125   FALSE FALSE
## accel_dumbbell_y      1.488889         9.900   FALSE FALSE
## accel_dumbbell_z      1.240000         6.875   FALSE FALSE
## accel_forearm_x       1.223881        13.000   FALSE FALSE
## accel_forearm_y       1.147059        20.250   FALSE FALSE
## accel_forearm_z       1.214286         9.225   FALSE FALSE
## gyros_belt_x          1.105023         3.375   FALSE FALSE
## gyros_belt_y          1.223844         1.250   FALSE FALSE
## gyros_belt_z          1.138587         2.450   FALSE FALSE
## gyros_arm_x           1.484375        13.550   FALSE FALSE
## gyros_arm_y           3.059524         7.925   FALSE FALSE
## gyros_arm_z           1.406977         5.300   FALSE FALSE
## gyros_dumbbell_x      2.088000         3.675   FALSE FALSE
## gyros_dumbbell_y      2.440299         6.825   FALSE FALSE
## gyros_dumbbell_z      1.479042         4.100   FALSE FALSE
## gyros_forearm_x       1.696970         5.325   FALSE FALSE
## gyros_forearm_y       1.011696        14.800   FALSE FALSE
## gyros_forearm_z       1.344156         6.750   FALSE FALSE
## magnet_belt_x         1.055814         6.150   FALSE FALSE
## magnet_belt_y         1.011429         4.650   FALSE FALSE
## magnet_belt_z         1.012048         9.275   FALSE FALSE
## magnet_arm_x          1.023810        28.675   FALSE FALSE
## magnet_arm_y          1.225000        20.400   FALSE FALSE
## magnet_arm_z          1.000000        25.925   FALSE FALSE
## magnet_dumbbell_x     1.673913        23.500   FALSE FALSE
## magnet_dumbbell_y     1.790698        18.375   FALSE FALSE
## magnet_dumbbell_z     2.047619        11.400   FALSE FALSE
## magnet_forearm_x      1.027027        23.150   FALSE FALSE
## magnet_forearm_y      1.085106        30.400   FALSE FALSE
## magnet_forearm_z      1.121212        26.875   FALSE FALSE
## roll_belt             1.343669        21.725   FALSE FALSE
## roll_arm              1.583333        30.850   FALSE FALSE
## roll_dumbbell         1.487179        90.700   FALSE FALSE
## roll_forearm          4.319444        10.725   FALSE FALSE
## pitch_belt            1.080745        20.525   FALSE FALSE
## pitch_arm             1.294118        42.250   FALSE FALSE
## pitch_dumbbell        1.603448        88.725   FALSE FALSE
## pitch_forearm         4.727273        33.900   FALSE FALSE
## yaw_belt              1.071429        23.375   FALSE FALSE
## yaw_arm               1.565789        41.625   FALSE FALSE
## yaw_dumbbell          4.461538        89.450   FALSE FALSE
## yaw_forearm           3.079208        16.500   FALSE FALSE
## total_accel_belt      1.260291         0.675   FALSE FALSE
## total_accel_arm       2.308989         1.475   FALSE FALSE
```

```
## total_accel_dumbbell  1.051867          0.825   FALSE FALSE
## total_accel_forearm   1.617486          1.200   FALSE FALSE
## Classe                1.003663          0.125   FALSE FALSE
```

```
qplot(x = trainPredSet[, "accel_belt_x"], y = trainPredSet[, "accel_arm_x"],c
olor = trainPredSet$classe)
```




```
set.seed(125)
inTrain <- createDataPartition(y = trainPredSet$classe, p = 0.8, list = FALSE
)
cvTrain <- trainPredSet[inTrain, ]
cvTest <- trainPredSet[-inTrain, ]
fitCtrl <- trainControl(method = "repeatedcv", number = 10, repeats = 10)
set.seed(125)
modFit <- train(classe ~ ., data = cvTrain, method = "qda", preProcess = c("c
enter","scale"), trControl = fitCtrl)

print(modFit)
```

```
## Quadratic Discriminant Analysis
##
## 3201 samples
##   52 predictor
##    5 classes: 'A', 'B', 'C', 'D', 'E'
##
## Pre-processing: centered (52), scaled (52)
## Resampling: Cross-Validated (10 fold, repeated 10 times)
```

```
## Summary of sample sizes: 2879, 2881, 2880, 2881, 2882, 2881, ...
## Resampling results:
##
##   Accuracy   Kappa
##   0.9821012  0.9746877
```

```
ptrain <- predict(modFit, newdata = cvTrain)
equalPredTrain <- (ptrain == cvTrain$classe)
print(sum(equalPredTrain)/length(equalPredTrain))
```

```
## [1] 0.9971884
```

```
confusionMatrix(data = ptrain, reference = cvTrain$classe)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1088    5    0    0    0
##          B    4  716    0    0    0
##          C    0    0   71    0    0
##          D    0    0    0  221    0
##          E    0    0    0    0 1096
##
## Overall Statistics
##
##                Accuracy : 0.9972
##                  95% CI : (0.9947, 0.9987)
##     No Information Rate : 0.3424
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.996
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.9963   0.9931  1.00000  1.00000   1.0000
## Specificity            0.9976   0.9984  1.00000  1.00000   1.0000
## Pos Pred Value         0.9954   0.9944  1.00000  1.00000   1.0000
## Neg Pred Value         0.9981   0.9980  1.00000  1.00000   1.0000
## Prevalence             0.3411   0.2252  0.02218  0.06904   0.3424
## Detection Rate         0.3399   0.2237  0.02218  0.06904   0.3424
## Detection Prevalence   0.3415   0.2249  0.02218  0.06904   0.3424
## Balanced Accuracy      0.9970   0.9957  1.00000  1.00000   1.0000
```

```
ptest <- predict(modFit, newdata = cvTest)
equalPredTest <- (ptest == cvTest$classe)
print(sum(equalPredTest)/length(equalPredTest))
```

```
## [1] 0.9899875
```

```
testPrediction <- predict(modFit, newdata = testing)
print(rbind(testing[1:20, 157], as.character(testPrediction)))

## Warning in rbind(testing[1:20, 157], as.character(testPrediction)): number
## of columns of result is not a multiple of vector length (arg 1)

##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
## [1,] "3"  "3"  "3"  "3"  "3"  "3"  "3"  "3"  "3"  "3"   "3"   "3"   "3"
## [2,] "B"  "B"  "B"  "B"  "B"  "B"  "B"  "B"  "B"  "B"   "B"   "B"   "B"
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24]
## [1,] "3"   "3"   "3"   "3"   "3"   "3"   "3"   "3"   "3"   "3"   "3"
## [2,] "B"   "B"   "B"   "B"   "B"   "B"   "B"   "B"   "B"   "B"   "B"
```