

WLE_classification.R, Feature selections

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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 `classe` 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 `classe`, 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 .

```

setwd("C:/Users/Seshan/Desktop/sv R related/acadgild/assignments/session19 Assignment")
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(training)),
                 grep("^magnet", names(training)), grep("^roll", names(training)),
                 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"], color = 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("center", "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)))

```

```
setwd("C:/Users/Seshan/Desktop/sv R related/acadgild/assignments/session19 Assignment")
```

```
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

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## 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
##

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## 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

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## 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_pitch_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

```



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## 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_pitch_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_pitch_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_pitch_belt"
## [13] "skewness_roll_belt" "skewness_roll_belt.1"
## [15] "max_roll_belt" "max_pitch_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_pitch_arm"	"kurtosis_yaw_arm"
## [69]	"skewness_roll_arm"	"skewness_pitch_arm"
## [71]	"skewness_yaw_arm"	"max_roll_arm"
## [73]	"max_pitch_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_pitch_dumbbell"	"kurtosis_yaw_dumbbell"
## [87]	"skewness_roll_dumbbell"	"skewness_pitch_dumbbell"
## [89]	"skewness_yaw_dumbbell"	"max_roll_dumbbell"
## [91]	"max_pitch_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_pitch_forearm"	"kurtosis_yaw_forearm"
## [125]	"skewness_roll_forearm"	"skewness_pitch_forearm"
## [127]	"skewness_yaw_forearm"	"max_roll_forearm"
## [129]	"max_pitch_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 3 ...
## $ raw_timestamp_part_1 : int 1322489729 1322489729 1322489729 1322489
729 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 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_pitch_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_pitch_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 -7.25 -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 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 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 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 -4.95 -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 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_pitch_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_pitch_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_pitch_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 ...
## $ 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_pitch_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

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## 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

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## 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_pitch_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_pitch_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
##

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## kurtosis_roll_dumbbell kurtosis_pitch_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_pitch_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

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## 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_pitch_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

```

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## Mean      :-0.04779      Mean      : 0.1687
## 3rd Qu.: -0.05065      3rd Qu.: 0.1729
## Max.      : 2.23660      Max.      : 3.5998
##
## max_roll_forearm max_pitch_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_pitch_forearm" "kurtosis_yaw_forearm"
## [125] "skewness_roll_forearm"  "skewness_pitch_forearm"
## [127] "skewness_yaw_forearm"   "max_roll_forearm"
## [129] "max_pitch_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(training)),
                  grep("^magnet", names(training)), grep("^roll", names(training)),
                  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

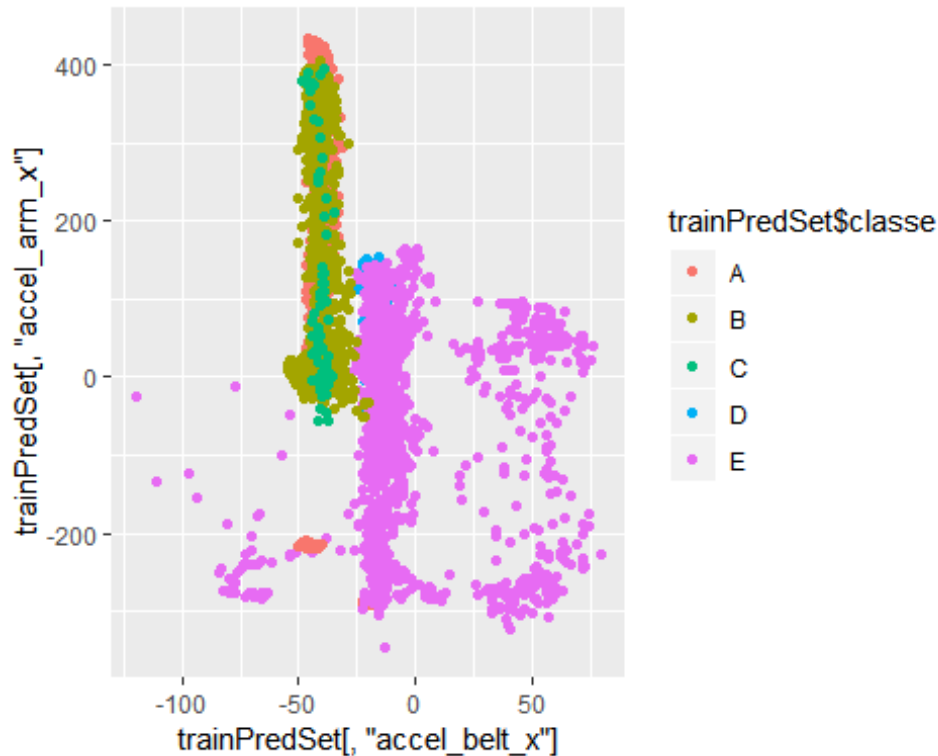
#sum(is.na(trainPredSet)) color = trainPredSet$classe)
nearZeroVar(trainPredSet[, -7], saveMetric = TRUE)

```

##	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
      color = 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"

```