

CourseProject:Prediction Assignment

Venkata Duvvuri

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Prediction Assignment

```
# required machine learning packages
#install.packages("caret")
#install.packages("randomForest")
#install.packages("rpart")
#install.packages("rpart.plot")
#install.packages("ROCR")
```

```
# Other required packages
#install.packages("tidyverse")
```

```
library(caret)
```

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

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

```
library(randomForest)
```

```
## randomForest 4.6-14
```

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

```
##
```

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

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

```
##
```

```
##      margin
```

```
library(rpart)
```

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

```
library(ROCR)
```

```
## Loading required package: gplots
```

```
##
```

```
## Attaching package: 'gplots'
```

```
## The following object is masked from 'package:stats':
```

```
##
```

```
##      lowess
```

```
library(tidyverse)
```

```
## -- Attaching packages ----- t
```

```
## v tibble  1.4.2    v purrr   0.2.4
```

```
## v tidyr   0.8.0    v dplyr   0.7.4
```

```
## v readr   1.1.1    v stringr 1.3.0
```

```
## v tibble  1.4.2    v forcats 0.3.0
```

```
## -- Conflicts ----- tidyverse
## x dplyr::combine()      masks randomForest::combine()
## x dplyr::filter()       masks stats::filter()
## x dplyr::lag()          masks stats::lag()
## x purrr::lift()         masks caret::lift()
## x randomForest::margin() masks ggplot2::margin()

# setting seed
set.seed(1234)
```

1. Load training and tests datasets from given urls.

```
trainingdata <- read.csv("https://d396qusza40orc.cloudfront.net/predmachlearn/pml-training.csv")
testdata <- read.csv("https://d396qusza40orc.cloudfront.net/predmachlearn/pml-testing.csv")
```

saved to local working directory

```
write.csv(trainingdata, "trainingdata.csv")
write.csv(testdata, "testdata.csv")
```

Structure of data

```
str(trainingdata)
```

```
## 'data.frame':   19622 obs. of  160 variables:
## $ X                : int  1 2 3 4 5 6 7 8 9 10 ...
## $ user_name        : Factor w/ 6 levels "adelmo","carlitos",...: 2 2 2 2 2 2 2 2 2 2 ...
## $ raw_timestamp_part_1 : int  1323084231 1323084231 1323084231 1323084232 1323084232 1323084232 1323084232 1323084232 1323084232 1323084232 ...
## $ raw_timestamp_part_2 : int  788290 808298 820366 120339 196328 304277 368296 440390 484323 484323 484323 484323 484323 484323 484323 484323 484323 484323 484323 484323 ...
## $ cvtd_timestamp      : Factor w/ 20 levels "02/12/2011 13:32",...: 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 ...
## $ new_window          : Factor w/ 2 levels "no","yes": 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 ...
## $ num_window          : int  11 11 11 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 ...
## $ roll_belt           : num  1.41 1.41 1.42 1.48 1.48 1.45 1.42 1.42 1.43 1.45 ...
## $ pitch_belt          : num  8.07 8.07 8.07 8.05 8.07 8.06 8.09 8.13 8.16 8.17 ...
## $ yaw_belt            : num  -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 ...
## $ total_accel_belt    : int  3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 ...
## $ kurtosis_roll_belt  : Factor w/ 397 levels "", "-0.016850",...: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 ...
## $ kurtosis_pitch_belt : Factor w/ 317 levels "", "-0.021887",...: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 ...
## $ kurtosis_yaw_belt   : Factor w/ 2 levels "", "#DIV/0!": 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 ...
## $ skewness_roll_belt  : Factor w/ 395 levels "", "-0.003095",...: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 ...
## $ skewness_roll_belt.1 : Factor w/ 338 levels "", "-0.005928",...: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 ...
## $ skewness_yaw_belt   : Factor w/ 2 levels "", "#DIV/0!": 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 ...
## $ max_roll_belt       : num  NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA ...
## $ max_pitch_belt      : int  NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA ...
## $ max_yaw_belt        : Factor w/ 68 levels "", "-0.1", "-0.2",...: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 ...
## $ min_roll_belt       : num  NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA ...
## $ min_pitch_belt      : int  NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA ...
## $ min_yaw_belt        : Factor w/ 68 levels "", "-0.1", "-0.2",...: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 ...
```

```

## $ amplitude_roll_belt      : num  NA NA NA NA NA NA NA NA NA NA ...
## $ amplitude_pitch_belt     : int   NA NA NA NA NA NA NA NA NA NA ...
## $ amplitude_yaw_belt       : Factor w/ 4 levels "", "#DIV/0!", "0.00", ...: 1 1 1 1 1 1 1 1 1 1 ...
## $ var_total_accel_belt     : num  NA NA NA NA NA NA NA NA NA NA ...
## $ avg_roll_belt            : num  NA NA NA NA NA NA NA NA NA NA ...
## $ stddev_roll_belt         : num  NA NA NA NA NA NA NA NA NA NA ...
## $ var_roll_belt            : num  NA NA NA NA NA NA NA NA NA NA ...
## $ avg_pitch_belt           : num  NA NA NA NA NA NA NA NA NA NA ...
## $ stddev_pitch_belt        : num  NA NA NA NA NA NA NA NA NA NA ...
## $ var_pitch_belt           : num  NA NA NA NA NA NA NA NA NA NA ...
## $ avg_yaw_belt             : num  NA NA NA NA NA NA NA NA NA NA ...
## $ stddev_yaw_belt          : num  NA NA NA NA NA NA NA NA NA NA ...
## $ var_yaw_belt             : num  NA NA NA NA NA NA NA NA NA NA ...
## $ gyros_belt_x             : num  0 0.02 0 0.02 0.02 0.02 0.02 0.02 0.02 0.03 ...
## $ gyros_belt_y             : num  0 0 0 0 0.02 0 0 0 0 0 ...
## $ gyros_belt_z             : num  -0.02 -0.02 -0.02 -0.03 -0.02 -0.02 -0.02 -0.02 -0.02 0 ...
## $ accel_belt_x             : int   -21 -22 -20 -22 -21 -21 -22 -22 -20 -21 ...
## $ accel_belt_y             : int    4 4 5 3 2 4 3 4 2 4 ...
## $ accel_belt_z             : int   22 22 23 21 24 21 21 21 24 22 ...
## $ magnet_belt_x            : int   -3 -7 -2 -6 -6 0 -4 -2 1 -3 ...
## $ magnet_belt_y            : int  599 608 600 604 600 603 599 603 602 609 ...
## $ magnet_belt_z            : int  -313 -311 -305 -310 -302 -312 -311 -313 -312 -308 ...
## $ roll_arm                 : num  -128 -128 -128 -128 -128 -128 -128 -128 -128 -128 ...
## $ pitch_arm                : num  22.5 22.5 22.5 22.1 22.1 22 21.9 21.8 21.7 21.6 ...
## $ yaw_arm                  : num  -161 -161 -161 -161 -161 -161 -161 -161 -161 -161 ...
## $ total_accel_arm          : int   34 34 34 34 34 34 34 34 34 34 ...
## $ var_accel_arm            : num  NA NA NA NA NA NA NA NA NA NA ...
## $ avg_roll_arm             : num  NA NA NA NA NA NA NA NA NA NA ...
## $ stddev_roll_arm          : num  NA NA NA NA NA NA NA NA NA NA ...
## $ var_roll_arm             : num  NA NA NA NA NA NA NA NA NA NA ...
## $ avg_pitch_arm            : num  NA NA NA NA NA NA NA NA NA NA ...
## $ stddev_pitch_arm         : num  NA NA NA NA NA NA NA NA NA NA ...
## $ var_pitch_arm            : num  NA NA NA NA NA NA NA NA NA NA ...
## $ avg_yaw_arm              : num  NA NA NA NA NA NA NA NA NA NA ...
## $ stddev_yaw_arm           : num  NA NA NA NA NA NA NA NA NA NA ...
## $ var_yaw_arm              : num  NA NA NA NA NA NA NA NA NA NA ...
## $ gyros_arm_x              : num  0 0.02 0.02 0.02 0 0.02 0 0.02 0.02 0.02 ...
## $ gyros_arm_y              : num  0 -0.02 -0.02 -0.03 -0.03 -0.03 -0.03 -0.02 -0.03 -0.03 ...
## $ gyros_arm_z              : num  -0.02 -0.02 -0.02 0.02 0 0 0 0 -0.02 -0.02 ...
## $ accel_arm_x              : int  -288 -290 -289 -289 -289 -289 -289 -289 -288 -288 ...
## $ accel_arm_y              : int  109 110 110 111 111 111 111 111 109 110 ...
## $ accel_arm_z              : int  -123 -125 -126 -123 -123 -122 -125 -124 -122 -124 ...
## $ magnet_arm_x             : int  -368 -369 -368 -372 -374 -369 -373 -372 -369 -376 ...
## $ magnet_arm_y             : int  337 337 344 344 337 342 336 338 341 334 ...
## $ magnet_arm_z             : int  516 513 513 512 506 513 509 510 518 516 ...
## $ kurtosis_roll_arm        : Factor w/ 330 levels "", "-0.02438", ...: 1 1 1 1 1 1 1 1 1 1 ...
## $ kurtosis_pitch_arm       : Factor w/ 328 levels "", "-0.00484", ...: 1 1 1 1 1 1 1 1 1 1 ...
## $ kurtosis_yaw_arm         : Factor w/ 395 levels "", "-0.01548", ...: 1 1 1 1 1 1 1 1 1 1 ...
## $ skewness_roll_arm        : Factor w/ 331 levels "", "-0.00051", ...: 1 1 1 1 1 1 1 1 1 1 ...
## $ skewness_pitch_arm       : Factor w/ 328 levels "", "-0.00184", ...: 1 1 1 1 1 1 1 1 1 1 ...
## $ skewness_yaw_arm         : Factor w/ 395 levels "", "-0.00311", ...: 1 1 1 1 1 1 1 1 1 1 ...
## $ max_roll_arm             : num  NA NA NA NA NA NA NA NA NA NA ...
## $ max_pitch_arm            : num  NA NA NA NA NA NA NA NA NA NA ...
## $ max_yaw_arm              : int   NA NA NA NA NA NA NA NA NA NA ...

```

```
## $ min_roll_arm : num NA NA NA NA NA NA NA NA NA NA ...
## $ min_pitch_arm : num NA NA NA NA NA NA NA NA NA NA ...
## $ min_yaw_arm : int NA NA NA NA NA NA NA NA NA NA ...
## $ amplitude_roll_arm : num NA NA NA NA NA NA NA NA NA NA ...
## $ amplitude_pitch_arm : num NA NA NA NA NA NA NA NA NA NA ...
## $ amplitude_yaw_arm : int NA NA NA NA NA NA NA NA NA NA ...
## $ roll_dumbbell : num 13.1 13.1 12.9 13.4 13.4 ...
## $ pitch_dumbbell : num -70.5 -70.6 -70.3 -70.4 -70.4 ...
## $ yaw_dumbbell : num -84.9 -84.7 -85.1 -84.9 -84.9 ...
## $ kurtosis_roll_dumbbell : Factor w/ 398 levels "", "-0.0035", "-0.0073", ...: 1 1 1 1 1 1 1 1 1 1 ...
## $ kurtosis_pitch_dumbbell : Factor w/ 401 levels "", "-0.0163", "-0.0233", ...: 1 1 1 1 1 1 1 1 1 1 ...
## $ kurtosis_yaw_dumbbell : Factor w/ 2 levels "", "#DIV/0!": 1 1 1 1 1 1 1 1 1 1 ...
## $ skewness_roll_dumbbell : Factor w/ 401 levels "", "-0.0082", "-0.0096", ...: 1 1 1 1 1 1 1 1 1 1 ...
## $ skewness_pitch_dumbbell : Factor w/ 402 levels "", "-0.0053", "-0.0084", ...: 1 1 1 1 1 1 1 1 1 1 ...
## $ skewness_yaw_dumbbell : Factor w/ 2 levels "", "#DIV/0!": 1 1 1 1 1 1 1 1 1 1 ...
## $ max_roll_dumbbell : num NA NA NA NA NA NA NA NA NA NA ...
## $ max_pitch_dumbbell : num NA NA NA NA NA NA NA NA NA NA ...
## $ max_yaw_dumbbell : Factor w/ 73 levels "", "-0.1", "-0.2", ...: 1 1 1 1 1 1 1 1 1 1 ...
## $ min_roll_dumbbell : num NA NA NA NA NA NA NA NA NA NA ...
## $ min_pitch_dumbbell : num NA NA NA NA NA NA NA NA NA NA ...
## $ min_yaw_dumbbell : Factor w/ 73 levels "", "-0.1", "-0.2", ...: 1 1 1 1 1 1 1 1 1 1 ...
## $ amplitude_roll_dumbbell : num NA NA NA NA NA NA NA NA NA NA ...
## [list output truncated]
```

```
str(testdata)
```

```
## 'data.frame': 20 obs. of 160 variables:
## $ X : int 1 2 3 4 5 6 7 8 9 10 ...
## $ user_name : Factor w/ 6 levels "adelmo","carlitos",...: 6 5 5 1 4 5 5 2 3 ...
## $ raw_timestamp_part_1 : int 1323095002 1322673067 1322673075 1322832789 1322489635 1322673149 ...
## $ raw_timestamp_part_2 : int 868349 778725 342967 560311 814776 510661 766645 54671 916313 3842 ...
## $ cvtd_timestamp : Factor w/ 11 levels "02/12/2011 13:33",...: 5 10 10 1 6 11 11 10 3 2 ...
## $ new_window : Factor w/ 1 level "no": 1 1 1 1 1 1 1 1 1 1 ...
## $ num_window : int 74 431 439 194 235 504 485 440 323 664 ...
## $ roll_belt : num 123 1.02 0.87 125 1.35 -5.92 1.2 0.43 0.93 114 ...
## $ pitch_belt : num 27 4.87 1.82 -41.6 3.33 1.59 4.44 4.15 6.72 22.4 ...
## $ yaw_belt : num -4.75 -88.9 -88.5 162 -88.6 -87.7 -87.3 -88.5 -93.7 -13.1 ...
## $ total_accel_belt : int 20 4 5 17 3 4 4 4 4 18 ...
## $ kurtosis_roll_belt : logi NA NA NA NA NA NA ...
## $ kurtosis_pitch_belt : logi NA NA NA NA NA NA ...
## $ kurtosis_yaw_belt : logi NA NA NA NA NA NA ...
## $ skewness_roll_belt : logi NA NA NA NA NA NA ...
## $ skewness_roll_belt.1 : logi NA NA NA NA NA NA ...
## $ skewness_yaw_belt : logi NA NA NA NA NA NA ...
## $ max_roll_belt : logi NA NA NA NA NA NA ...
## $ max_pitch_belt : logi NA NA NA NA NA NA ...
## $ max_yaw_belt : logi NA NA NA NA NA NA ...
## $ min_roll_belt : logi NA NA NA NA NA NA ...
## $ min_pitch_belt : logi NA NA NA NA NA NA ...
## $ min_yaw_belt : logi NA NA NA NA NA NA ...
## $ amplitude_roll_belt : logi NA NA NA NA NA NA ...
## $ amplitude_pitch_belt : logi NA NA NA NA NA NA ...
## $ amplitude_yaw_belt : logi NA NA NA NA NA NA ...
## $ var_total_accel_belt : logi NA NA NA NA NA NA ...
## $ avg_roll_belt : logi NA NA NA NA NA NA ...
```

```

## $ stddev_roll_belt      : logi  NA NA NA NA NA NA ...
## $ var_roll_belt         : logi  NA NA NA NA NA NA ...
## $ avg_pitch_belt        : logi  NA NA NA NA NA NA ...
## $ stddev_pitch_belt     : logi  NA NA NA NA NA NA ...
## $ var_pitch_belt        : logi  NA NA NA NA NA NA ...
## $ avg_yaw_belt          : logi  NA NA NA NA NA NA ...
## $ stddev_yaw_belt       : logi  NA NA NA NA NA NA ...
## $ var_yaw_belt          : logi  NA NA NA NA NA NA ...
## $ gyros_belt_x          : num  -0.5 -0.06 0.05 0.11 0.03 0.1 -0.06 -0.18 0.1 0.14 ...
## $ gyros_belt_y          : num  -0.02 -0.02 0.02 0.11 0.02 0.05 0 -0.02 0 0.11 ...
## $ gyros_belt_z          : num  -0.46 -0.07 0.03 -0.16 0 -0.13 0 -0.03 -0.02 -0.16 ...
## $ accel_belt_x          : int   -38 -13 1 46 -8 -11 -14 -10 -15 -25 ...
## $ accel_belt_y          : int    69 11 -1 45 4 -16 2 -2 1 63 ...
## $ accel_belt_z          : int  -179 39 49 -156 27 38 35 42 32 -158 ...
## $ magnet_belt_x         : int   -13 43 29 169 33 31 50 39 -6 10 ...
## $ magnet_belt_y         : int   581 636 631 608 566 638 622 635 600 601 ...
## $ magnet_belt_z         : int  -382 -309 -312 -304 -418 -291 -315 -305 -302 -330 ...
## $ roll_arm              : num   40.7 0 0 -109 76.1 0 0 0 -137 -82.4 ...
## $ pitch_arm             : num  -27.8 0 0 55 2.76 0 0 0 11.2 -63.8 ...
## $ yaw_arm               : num   178 0 0 -142 102 0 0 0 -167 -75.3 ...
## $ total_accel_arm       : int    10 38 44 25 29 14 15 22 34 32 ...
## $ var_accel_arm         : logi  NA NA NA NA NA NA ...
## $ avg_roll_arm          : logi  NA NA NA NA NA NA ...
## $ stddev_roll_arm       : logi  NA NA NA NA NA NA ...
## $ var_roll_arm          : logi  NA NA NA NA NA NA ...
## $ avg_pitch_arm         : logi  NA NA NA NA NA NA ...
## $ stddev_pitch_arm      : logi  NA NA NA NA NA NA ...
## $ var_pitch_arm         : logi  NA NA NA NA NA NA ...
## $ avg_yaw_arm           : logi  NA NA NA NA NA NA ...
## $ stddev_yaw_arm        : logi  NA NA NA NA NA NA ...
## $ var_yaw_arm           : logi  NA NA NA NA NA NA ...
## $ gyros_arm_x           : num  -1.65 -1.17 2.1 0.22 -1.96 0.02 2.36 -3.71 0.03 0.26 ...
## $ gyros_arm_y           : num   0.48 0.85 -1.36 -0.51 0.79 0.05 -1.01 1.85 -0.02 -0.5 ...
## $ gyros_arm_z           : num  -0.18 -0.43 1.13 0.92 -0.54 -0.07 0.89 -0.69 -0.02 0.79 ...
## $ accel_arm_x           : int    16 -290 -341 -238 -197 -26 99 -98 -287 -301 ...
## $ accel_arm_y           : int    38 215 245 -57 200 130 79 175 111 -42 ...
## $ accel_arm_z           : int    93 -90 -87 6 -30 -19 -67 -78 -122 -80 ...
## $ magnet_arm_x          : int  -326 -325 -264 -173 -170 396 702 535 -367 -420 ...
## $ magnet_arm_y          : int   385 447 474 257 275 176 15 215 335 294 ...
## $ magnet_arm_z          : int   481 434 413 633 617 516 217 385 520 493 ...
## $ kurtosis_roll_arm     : logi  NA NA NA NA NA NA ...
## $ kurtosis_pitch_arm    : logi  NA NA NA NA NA NA ...
## $ kurtosis_yaw_arm      : logi  NA NA NA NA NA NA ...
## $ skewness_roll_arm     : logi  NA NA NA NA NA NA ...
## $ skewness_pitch_arm    : logi  NA NA NA NA NA NA ...
## $ skewness_yaw_arm      : logi  NA NA NA NA NA NA ...
## $ max_roll_arm          : logi  NA NA NA NA NA NA ...
## $ max_pitch_arm         : logi  NA NA NA NA NA NA ...
## $ max_yaw_arm           : logi  NA NA NA NA NA NA ...
## $ min_roll_arm          : logi  NA NA NA NA NA NA ...
## $ min_pitch_arm         : logi  NA NA NA NA NA NA ...
## $ min_yaw_arm           : logi  NA NA NA NA NA NA ...
## $ amplitude_roll_arm    : logi  NA NA NA NA NA NA ...
## $ amplitude_pitch_arm   : logi  NA NA NA NA NA NA ...

```

```
## $ amplitude_yaw_arm      : logi  NA NA NA NA NA NA ...
## $ roll_dumbbell         : num   -17.7 54.5 57.1 43.1 -101.4 ...
## $ pitch_dumbbell        : num    25 -53.7 -51.4 -30 -53.4 ...
## $ yaw_dumbbell          : num   126.2 -75.5 -75.2 -103.3 -14.2 ...
## $ kurtosis_roll_dumbbell : logi   NA NA NA NA NA NA ...
## $ kurtosis_pitch_dumbbell : logi   NA NA NA NA NA NA ...
## $ kurtosis_yaw_dumbbell  : logi   NA NA NA NA NA NA ...
## $ skewness_roll_dumbbell : logi   NA NA NA NA NA NA ...
## $ skewness_pitch_dumbbell : logi   NA NA NA NA NA NA ...
## $ skewness_yaw_dumbbell  : logi   NA NA NA NA NA NA ...
## $ max_roll_dumbbell      : logi   NA NA NA NA NA NA ...
## $ max_pitch_dumbbell     : logi   NA NA NA NA NA NA ...
## $ max_yaw_dumbbell       : logi   NA NA NA NA NA NA ...
## $ min_roll_dumbbell      : logi   NA NA NA NA NA NA ...
## $ min_pitch_dumbbell     : logi   NA NA NA NA NA NA ...
## $ min_yaw_dumbbell       : logi   NA NA NA NA NA NA ...
## $ amplitude_roll_dumbbell : logi   NA NA NA NA NA NA ...
## [list output truncated]
```

The results from structure of data revealed that datasets contains missing values as "#DIV/0!". Replac

#2. Pre-processing of datasets. Remove “NA”, “#DIV/0!” from data

```
traindata <- read.csv("trainingdata.csv", na.strings=c("NA", "#DIV/0!", ""))
write.csv(traindata, "traindata.csv")
testdata<-read.csv("testdata.csv", na.strings=c("NA", "#DIV/0!", ""))
write.csv(traindata, "testdata.csv")
```

Check dimensions for number of variables and number of observations

```
dim(traindata)
```

```
## [1] 19622 161
```

```
dim(testdata)
```

```
## [1] 20 161
```

summary of training and test data

```
summary(traindata)
```

```
##      X.1      X      user_name      raw_timestamp_part_1
## Min.   :    1  Min.   :    1  adelmo :3892  Min.   :1.322e+09
## 1st Qu.: 4906  1st Qu.: 4906  carlitos:3112 1st Qu.:1.323e+09
## Median : 9812  Median : 9812  charles :3536  Median :1.323e+09
```

```

## Mean : 9812 Mean : 9812 eurico :3070 Mean :1.323e+09
## 3rd Qu.:14717 3rd Qu.:14717 jeremy :3402 3rd Qu.:1.323e+09
## Max. :19622 Max. :19622 pedro :2610 Max. :1.323e+09
##
## raw_timestamp_part_2 cvtd_timestamp new_window num_window
## Min. : 294 28/11/2011 14:14: 1498 no :19216 Min. : 1.0
## 1st Qu.:252912 05/12/2011 11:24: 1497 yes: 406 1st Qu.:222.0
## Median :496380 30/11/2011 17:11: 1440 Median :424.0
## Mean :500656 05/12/2011 11:25: 1425 Mean :430.6
## 3rd Qu.:751891 02/12/2011 14:57: 1380 3rd Qu.:644.0
## Max. :998801 02/12/2011 13:34: 1375 Max. :864.0
## (Other) :11007
## roll_belt pitch_belt yaw_belt total_accel_belt
## Min. :-28.90 Min. :-55.8000 Min. :-180.00 Min. : 0.00
## 1st Qu.: 1.10 1st Qu.: 1.7600 1st Qu.: -88.30 1st Qu.: 3.00
## Median :113.00 Median : 5.2800 Median : -13.00 Median :17.00
## Mean : 64.41 Mean : 0.3053 Mean : -11.21 Mean :11.31
## 3rd Qu.:123.00 3rd Qu.: 14.9000 3rd Qu.: 12.90 3rd Qu.:18.00
## Max. :162.00 Max. : 60.3000 Max. : 179.00 Max. :29.00
##
## kurtosis_roll_belt kurtosis_pitch_belt kurtosis_yaw_belt
## Min. :-2.121 Min. :-2.190 Mode:logical
## 1st Qu.: -1.329 1st Qu.: -1.107 NA's:19622
## Median : -0.899 Median : -0.151
## Mean : -0.220 Mean : 4.334
## 3rd Qu.: -0.219 3rd Qu.: 3.178
## Max. :33.000 Max. :58.000
## NA's :19226 NA's :19248
## skewness_roll_belt skewness_roll_belt.1 skewness_yaw_belt
## Min. :-5.745 Min. :-7.616 Mode:logical
## 1st Qu.: -0.444 1st Qu.: -1.114 NA's:19622
## Median : 0.000 Median : -0.068
## Mean : -0.026 Mean : -0.296
## 3rd Qu.: 0.417 3rd Qu.: 0.661
## Max. : 3.595 Max. : 7.348
## NA's :19225 NA's :19248
## max_roll_belt max_pitch_belt max_yaw_belt min_roll_belt
## Min. :-94.300 Min. : 3.00 Min. :-2.10 Min. :-180.00
## 1st Qu.: -88.000 1st Qu.: 5.00 1st Qu.: -1.30 1st Qu.: -88.40
## Median : -5.100 Median :18.00 Median : -0.90 Median : -7.85
## Mean : -6.667 Mean :12.92 Mean : -0.22 Mean : -10.44
## 3rd Qu.: 18.500 3rd Qu.:19.00 3rd Qu.: -0.20 3rd Qu.: 9.05
## Max. :180.000 Max. :30.00 Max. :33.00 Max. : 173.00
## NA's :19216 NA's :19216 NA's :19226 NA's :19216
## min_pitch_belt min_yaw_belt amplitude_roll_belt amplitude_pitch_belt
## Min. : 0.00 Min. :-2.10 Min. : 0.000 Min. : 0.000
## 1st Qu.: 3.00 1st Qu.: -1.30 1st Qu.: 0.300 1st Qu.: 1.000
## Median :16.00 Median : -0.90 Median : 1.000 Median : 1.000
## Mean :10.76 Mean : -0.22 Mean : 3.769 Mean : 2.167
## 3rd Qu.:17.00 3rd Qu.: -0.20 3rd Qu.: 2.083 3rd Qu.: 2.000
## Max. :23.00 Max. :33.00 Max. :360.000 Max. :12.000
## NA's :19216 NA's :19226 NA's :19216 NA's :19216
## amplitude_yaw_belt var_total_accel_belt avg_roll_belt stddev_roll_belt
## Min. :0 Min. : 0.000 Min. : -27.40 Min. : 0.000

```

```

## 1st Qu.:0      1st Qu.: 0.100      1st Qu.: 1.10      1st Qu.: 0.200
## Median :0      Median : 0.200      Median :116.35      Median : 0.400
## Mean :0      Mean : 0.926      Mean : 68.06      Mean : 1.337
## 3rd Qu.:0      3rd Qu.: 0.300      3rd Qu.:123.38      3rd Qu.: 0.700
## Max. :0      Max. :16.500      Max. :157.40      Max. :14.200
## NA's :19226      NA's :19216      NA's :19216      NA's :19216
## var_roll_belt      avg_pitch_belt      stddev_pitch_belt      var_pitch_belt
## Min. : 0.000      Min. : -51.400      Min. :0.000      Min. : 0.000
## 1st Qu.: 0.000      1st Qu.: 2.025      1st Qu.:0.200      1st Qu.: 0.000
## Median : 0.100      Median : 5.200      Median :0.400      Median : 0.100
## Mean : 7.699      Mean : 0.520      Mean :0.603      Mean : 0.766
## 3rd Qu.: 0.500      3rd Qu.: 15.775      3rd Qu.:0.700      3rd Qu.: 0.500
## Max. :200.700      Max. : 59.700      Max. :4.000      Max. :16.200
## NA's :19216      NA's :19216      NA's :19216      NA's :19216
## avg_yaw_belt      stddev_yaw_belt      var_yaw_belt
## Min. : -138.300      Min. : 0.000      Min. : 0.000
## 1st Qu.: -88.175      1st Qu.: 0.100      1st Qu.: 0.010
## Median : -6.550      Median : 0.300      Median : 0.090
## Mean : -8.831      Mean : 1.341      Mean : 107.487
## 3rd Qu.: 14.125      3rd Qu.: 0.700      3rd Qu.: 0.475
## Max. : 173.500      Max. :176.600      Max. :31183.240
## NA's :19216      NA's :19216      NA's :19216
## gyros_belt_x      gyros_belt_y      gyros_belt_z
## Min. : -1.040000      Min. : -0.64000      Min. : -1.4600
## 1st Qu.: -0.030000      1st Qu.: 0.00000      1st Qu.: -0.2000
## Median : 0.030000      Median : 0.02000      Median : -0.1000
## Mean : -0.005592      Mean : 0.03959      Mean : -0.1305
## 3rd Qu.: 0.110000      3rd Qu.: 0.11000      3rd Qu.: -0.0200
## Max. : 2.220000      Max. : 0.64000      Max. : 1.6200
##
## accel_belt_x      accel_belt_y      accel_belt_z      magnet_belt_x
## Min. : -120.000      Min. : -69.00      Min. : -275.00      Min. : -52.0
## 1st Qu.: -21.000      1st Qu.: 3.00      1st Qu.: -162.00      1st Qu.: 9.0
## Median : -15.000      Median : 35.00      Median : -152.00      Median : 35.0
## Mean : -5.595      Mean : 30.15      Mean : -72.59      Mean : 55.6
## 3rd Qu.: -5.000      3rd Qu.: 61.00      3rd Qu.: 27.00      3rd Qu.: 59.0
## Max. : 85.000      Max. :164.00      Max. : 105.00      Max. :485.0
##
## magnet_belt_y      magnet_belt_z      roll_arm      pitch_arm
## Min. :354.0      Min. : -623.0      Min. : -180.00      Min. : -88.800
## 1st Qu.:581.0      1st Qu.: -375.0      1st Qu.: -31.77      1st Qu.: -25.900
## Median :601.0      Median : -320.0      Median : 0.00      Median : 0.000
## Mean :593.7      Mean : -345.5      Mean : 17.83      Mean : -4.612
## 3rd Qu.:610.0      3rd Qu.: -306.0      3rd Qu.: 77.30      3rd Qu.: 11.200
## Max. :673.0      Max. : 293.0      Max. : 180.00      Max. : 88.500
##
## yaw_arm      total_accel_arm      var_accel_arm      avg_roll_arm
## Min. : -180.0000      Min. : 1.00      Min. : 0.00      Min. : -166.67
## 1st Qu.: -43.1000      1st Qu.:17.00      1st Qu.: 9.03      1st Qu.: -38.37
## Median : 0.0000      Median :27.00      Median : 40.61      Median : 0.00
## Mean : -0.6188      Mean :25.51      Mean : 53.23      Mean : 12.68
## 3rd Qu.: 45.8750      3rd Qu.:33.00      3rd Qu.: 75.62      3rd Qu.: 76.33
## Max. : 180.0000      Max. :66.00      Max. :331.70      Max. : 163.33
##
## NA's :19216      NA's :19216

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## stddev_roll_arm    var_roll_arm    avg_pitch_arm    stddev_pitch_arm
## Min.   : 0.000    Min.   : 0.000    Min.   : -81.773    Min.   : 0.000
## 1st Qu.: 1.376    1st Qu.: 1.898    1st Qu.: -22.770    1st Qu.: 1.642
## Median : 5.702    Median : 32.517    Median : 0.000     Median : 8.133
## Mean   : 11.201    Mean   : 417.264    Mean   : -4.901     Mean   : 10.383
## 3rd Qu.: 14.921    3rd Qu.: 222.647    3rd Qu.: 8.277     3rd Qu.: 16.327
## Max.   : 161.964    Max.   : 26232.208    Max.   : 75.659     Max.   : 43.412
## NA's   :19216     NA's   :19216     NA's   :19216     NA's   :19216
## var_pitch_arm      avg_yaw_arm      stddev_yaw_arm
## Min.   : 0.000     Min.   : -173.440    Min.   : 0.000
## 1st Qu.: 2.697     1st Qu.: -29.198    1st Qu.: 2.577
## Median : 66.146     Median : 0.000      Median : 16.682
## Mean   : 195.864     Mean   : 2.359      Mean   : 22.270
## 3rd Qu.: 266.576     3rd Qu.: 38.185    3rd Qu.: 35.984
## Max.   : 1884.565    Max.   : 152.000     Max.   : 177.044
## NA's   :19216     NA's   :19216     NA's   :19216
## var_yaw_arm        gyros_arm_x        gyros_arm_y
## Min.   : 0.000     Min.   : -6.37000    Min.   : -3.4400
## 1st Qu.: 6.642     1st Qu.: -1.33000    1st Qu.: -0.8000
## Median : 278.309    Median : 0.08000     Median : -0.2400
## Mean   : 1055.933    Mean   : 0.04277     Mean   : -0.2571
## 3rd Qu.: 1294.850    3rd Qu.: 1.57000     3rd Qu.: 0.1400
## Max.   : 31344.568    Max.   : 4.87000     Max.   : 2.8400
## NA's   :19216
## gyros_arm_z        accel_arm_x        accel_arm_y        accel_arm_z
## Min.   : -2.3300    Min.   : -404.00     Min.   : -318.0     Min.   : -636.00
## 1st Qu.: -0.0700    1st Qu.: -242.00     1st Qu.: -54.0      1st Qu.: -143.00
## Median : 0.2300     Median : -44.00      Median : 14.0       Median : -47.00
## Mean   : 0.2695     Mean   : -60.24      Mean   : 32.6        Mean   : -71.25
## 3rd Qu.: 0.7200     3rd Qu.: 84.00       3rd Qu.: 139.0      3rd Qu.: 23.00
## Max.   : 3.0200     Max.   : 437.00      Max.   : 308.0       Max.   : 292.00
##
## magnet_arm_x        magnet_arm_y        magnet_arm_z        kurtosis_roll_arm
## Min.   : -584.0     Min.   : -392.0     Min.   : -597.0     Min.   : -1.809
## 1st Qu.: -300.0     1st Qu.: -9.0       1st Qu.: 131.2      1st Qu.: -1.345
## Median : 289.0       Median : 202.0      Median : 444.0      Median : -0.894
## Mean   : 191.7       Mean   : 156.6       Mean   : 306.5       Mean   : -0.366
## 3rd Qu.: 637.0       3rd Qu.: 323.0      3rd Qu.: 545.0      3rd Qu.: -0.038
## Max.   : 782.0       Max.   : 583.0       Max.   : 694.0       Max.   : 21.456
## NA's   :19294
## kurtosis_pitch_arm kurtosis_yaw_arm skewness_roll_arm skewness_pitch_arm
## Min.   : -2.084     Min.   : -2.103     Min.   : -2.541     Min.   : -4.565
## 1st Qu.: -1.280     1st Qu.: -1.220     1st Qu.: -0.561     1st Qu.: -0.618
## Median : -1.010     Median : -0.733     Median : 0.040      Median : -0.035
## Mean   : -0.542     Mean   : 0.406       Mean   : 0.068       Mean   : -0.065
## 3rd Qu.: -0.379     3rd Qu.: 0.115      3rd Qu.: 0.671      3rd Qu.: 0.454
## Max.   : 19.751     Max.   : 56.000      Max.   : 4.394       Max.   : 3.043
## NA's   :19296     NA's   :19227      NA's   :19293      NA's   :19296
## skewness_yaw_arm    max_roll_arm        max_pitch_arm        max_yaw_arm
## Min.   : -6.708     Min.   : -73.100    Min.   : -173.000    Min.   : 4.00
## 1st Qu.: -0.743     1st Qu.: -0.175     1st Qu.: -1.975     1st Qu.: 29.00
## Median : -0.133     Median : 4.950      Median : 23.250     Median : 34.00
## Mean   : -0.229     Mean   : 11.236     Mean   : 35.751     Mean   : 35.46
## 3rd Qu.: 0.344      3rd Qu.: 26.775     3rd Qu.: 95.975     3rd Qu.: 41.00

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## Max. : 7.483 Max. : 85.500 Max. : 180.000 Max. : 65.00
## NA's :19227 NA's :19216 NA's :19216 NA's :19216
## min_roll_arm min_pitch_arm min_yaw_arm amplitude_roll_arm
## Min. : -89.10 Min. : -180.00 Min. : 1.00 Min. : 0.000
## 1st Qu.: -41.98 1st Qu.: -72.62 1st Qu.: 8.00 1st Qu.: 5.425
## Median : -22.45 Median : -33.85 Median : 13.00 Median : 28.450
## Mean : -21.22 Mean : -33.92 Mean : 14.66 Mean : 32.452
## 3rd Qu.: 0.00 3rd Qu.: 0.00 3rd Qu.: 19.00 3rd Qu.: 50.960
## Max. : 66.40 Max. : 152.00 Max. : 38.00 Max. : 119.500
## NA's :19216 NA's :19216 NA's :19216 NA's :19216
## amplitude_pitch_arm amplitude_yaw_arm roll_dumbbell pitch_dumbbell
## Min. : 0.000 Min. : 0.00 Min. : -153.71 Min. : -149.59
## 1st Qu.: 9.925 1st Qu.: 13.00 1st Qu.: -18.49 1st Qu.: -40.89
## Median : 54.900 Median : 22.00 Median : 48.17 Median : -20.96
## Mean : 69.677 Mean : 20.79 Mean : 23.84 Mean : -10.78
## 3rd Qu.: 115.175 3rd Qu.: 28.75 3rd Qu.: 67.61 3rd Qu.: 17.50
## Max. : 360.000 Max. : 52.00 Max. : 153.55 Max. : 149.40
## NA's :19216 NA's :19216
## yaw_dumbbell kurtosis_roll_dumbbell kurtosis_pitch_dumbbell
## Min. : -150.871 Min. : -2.174 Min. : -2.200
## 1st Qu.: -77.644 1st Qu.: -0.682 1st Qu.: -0.721
## Median : -3.324 Median : -0.033 Median : -0.133
## Mean : 1.674 Mean : 0.452 Mean : 0.286
## 3rd Qu.: 79.643 3rd Qu.: 0.940 3rd Qu.: 0.584
## Max. : 154.952 Max. : 54.998 Max. : 55.628
## NA's :19221 NA's :19218
## kurtosis_yaw_dumbbell skewness_roll_dumbbell skewness_pitch_dumbbell
## Mode:logical Min. : -7.384 Min. : -7.447
## NA's:19622 1st Qu.: -0.581 1st Qu.: -0.526
## Median : -0.076 Median : -0.091
## Mean : -0.115 Mean : -0.035
## 3rd Qu.: 0.400 3rd Qu.: 0.505
## Max. : 1.958 Max. : 3.769
## NA's :19220 NA's :19217
## skewness_yaw_dumbbell max_roll_dumbbell max_pitch_dumbbell
## Mode:logical Min. : -70.10 Min. : -112.90
## NA's:19622 1st Qu.: -27.15 1st Qu.: -66.70
## Median : 14.85 Median : 40.05
## Mean : 13.76 Mean : 32.75
## 3rd Qu.: 50.58 3rd Qu.: 133.22
## Max. : 137.00 Max. : 155.00
## NA's :19216 NA's :19216
## max_yaw_dumbbell min_roll_dumbbell min_pitch_dumbbell min_yaw_dumbbell
## Min. : -2.20 Min. : -149.60 Min. : -147.00 Min. : -2.20
## 1st Qu.: -0.70 1st Qu.: -59.67 1st Qu.: -91.80 1st Qu.: -0.70
## Median : 0.00 Median : -43.55 Median : -66.15 Median : 0.00
## Mean : 0.45 Mean : -41.24 Mean : -33.18 Mean : 0.45
## 3rd Qu.: 0.90 3rd Qu.: -25.20 3rd Qu.: 21.20 3rd Qu.: 0.90
## Max. : 55.00 Max. : 73.20 Max. : 120.90 Max. : 55.00
## NA's :19221 NA's :19216 NA's :19216 NA's :19221
## amplitude_roll_dumbbell amplitude_pitch_dumbbell amplitude_yaw_dumbbell
## Min. : 0.00 Min. : 0.00 Min. : 0
## 1st Qu.: 14.97 1st Qu.: 17.06 1st Qu.: 0
## Median : 35.05 Median : 41.73 Median : 0

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## Mean      : 55.00          Mean      : 65.93          Mean      :0
## 3rd Qu.: 81.04          3rd Qu.: 99.55          3rd Qu.:0
## Max.     :256.48        Max.     :273.59        Max.     :0
## NA's     :19216        NA's     :19216        NA's     :19221
## total_accel_dumbbell var_accel_dumbbell avg_roll_dumbbell
## Min.      : 0.00        Min.      : 0.000        Min.      : -128.96
## 1st Qu.: 4.00          1st Qu.: 0.378        1st Qu.: -12.33
## Median :10.00          Median : 1.000        Median : 48.23
## Mean      :13.72        Mean      : 4.388        Mean      : 23.86
## 3rd Qu.:19.00          3rd Qu.: 3.434        3rd Qu.: 64.37
## Max.      :58.00        Max.      :230.428      Max.      : 125.99
## NA's      :19216        NA's      :19216        NA's      :19216
## stddev_roll_dumbbell var_roll_dumbbell avg_pitch_dumbbell
## Min.      : 0.000        Min.      : 0.00        Min.      : -70.73
## 1st Qu.: 4.639          1st Qu.: 21.52        1st Qu.: -42.00
## Median : 12.204          Median : 148.95        Median : -19.91
## Mean      : 20.761        Mean      : 1020.27      Mean      : -12.33
## 3rd Qu.: 26.356          3rd Qu.: 694.65        3rd Qu.: 13.21
## Max.      :123.778        Max.      :15321.01      Max.      : 94.28
## NA's      :19216        NA's      :19216        NA's      :19216
## stddev_pitch_dumbbell var_pitch_dumbbell avg_yaw_dumbbell
## Min.      : 0.000        Min.      : 0.00        Min.      : -117.950
## 1st Qu.: 3.482          1st Qu.: 12.12        1st Qu.: -76.696
## Median : 8.089          Median : 65.44        Median : -4.505
## Mean      :13.147        Mean      : 350.31      Mean      : 0.202
## 3rd Qu.:19.238          3rd Qu.: 370.11        3rd Qu.: 71.234
## Max.      :82.680        Max.      :6836.02      Max.      : 134.905
## NA's      :19216        NA's      :19216        NA's      :19216
## stddev_yaw_dumbbell var_yaw_dumbbell gyros_dumbbell_x
## Min.      : 0.000        Min.      : 0.00        Min.      : -204.0000
## 1st Qu.: 3.885          1st Qu.: 15.09        1st Qu.: -0.0300
## Median : 10.264          Median : 105.35        Median : 0.1300
## Mean      : 16.647        Mean      : 589.84      Mean      : 0.1611
## 3rd Qu.: 24.674          3rd Qu.: 608.79        3rd Qu.: 0.3500
## Max.      :107.088        Max.      :11467.91      Max.      : 2.2200
## NA's      :19216        NA's      :19216
## gyros_dumbbell_y gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y
## Min.      : -2.10000      Min.      : -2.380      Min.      : -419.00      Min.      : -189.00
## 1st Qu.: -0.14000        1st Qu.: -0.310        1st Qu.: -50.00      1st Qu.: -8.00
## Median : 0.03000          Median : -0.130        Median : -8.00      Median : 41.50
## Mean      : 0.04606        Mean      : -0.129        Mean      : -28.62      Mean      : 52.63
## 3rd Qu.: 0.21000          3rd Qu.: 0.030         3rd Qu.: 11.00      3rd Qu.: 111.00
## Max.      :52.00000        Max.      :317.000        Max.      : 235.00      Max.      : 315.00
##
## accel_dumbbell_z magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z
## Min.      : -334.00      Min.      : -643.0      Min.      : -3600      Min.      : -262.00
## 1st Qu.: -142.00        1st Qu.: -535.0        1st Qu.: 231         1st Qu.: -45.00
## Median : -1.00          Median : -479.0        Median : 311         Median : 13.00
## Mean      : -38.32        Mean      : -328.5        Mean      : 221         Mean      : 46.05
## 3rd Qu.: 38.00          3rd Qu.: -304.0        3rd Qu.: 390         3rd Qu.: 95.00
## Max.      : 318.00        Max.      : 592.0         Max.      : 633         Max.      : 452.00
##
## roll_forearm pitch_forearm yaw_forearm
## Min.      : -180.0000      Min.      : -72.50      Min.      : -180.00

```

```

## 1st Qu.: -0.7375 1st Qu.: 0.00 1st Qu.: -68.60
## Median : 21.7000 Median : 9.24 Median : 0.00
## Mean : 33.8265 Mean : 10.71 Mean : 19.21
## 3rd Qu.: 140.0000 3rd Qu.: 28.40 3rd Qu.: 110.00
## Max. : 180.0000 Max. : 89.80 Max. : 180.00
##
## kurtosis_roll_forearm kurtosis_pitch_forearm kurtosis_yaw_forearm
## Min. : -1.879 Min. : -2.098 Mode:logical
## 1st Qu.: -1.398 1st Qu.: -1.376 NA's:19622
## Median : -1.119 Median : -0.890
## Mean : -0.689 Mean : 0.419
## 3rd Qu.: -0.618 3rd Qu.: 0.054
## Max. : 40.060 Max. : 33.626
## NA's :19300 NA's :19301
## skewness_roll_forearm skewness_pitch_forearm skewness_yaw_forearm
## Min. : -2.297 Min. : -5.241 Mode:logical
## 1st Qu.: -0.402 1st Qu.: -0.881 NA's:19622
## Median : 0.003 Median : -0.156
## Mean : -0.009 Mean : -0.223
## 3rd Qu.: 0.370 3rd Qu.: 0.514
## Max. : 5.856 Max. : 4.464
## NA's :19299 NA's :19301
## max_roll_forearm max_pitch_forearm max_yaw_forearm min_roll_forearm
## Min. : -66.60 Min. : -151.00 Min. : -1.900 Min. : -72.500
## 1st Qu.: 0.00 1st Qu.: 0.00 1st Qu.: -1.400 1st Qu.: -6.075
## Median : 26.80 Median : 113.00 Median : -1.100 Median : 0.000
## Mean : 24.49 Mean : 81.49 Mean : -0.689 Mean : -0.167
## 3rd Qu.: 45.95 3rd Qu.: 174.75 3rd Qu.: -0.600 3rd Qu.: 12.075
## Max. : 89.80 Max. : 180.00 Max. : 40.100 Max. : 62.100
## NA's :19216 NA's :19216 NA's :19300 NA's :19216
## min_pitch_forearm min_yaw_forearm amplitude_roll_forearm
## Min. : -180.00 Min. : -1.900 Min. : 0.000
## 1st Qu.: -175.00 1st Qu.: -1.400 1st Qu.: 1.125
## Median : -61.00 Median : -1.100 Median : 17.770
## Mean : -57.57 Mean : -0.689 Mean : 24.653
## 3rd Qu.: 0.00 3rd Qu.: -0.600 3rd Qu.: 39.875
## Max. : 167.00 Max. : 40.100 Max. : 126.000
## NA's :19216 NA's :19300 NA's :19216
## amplitude_pitch_forearm amplitude_yaw_forearm total_accel_forearm
## Min. : 0.0 Min. : 0 Min. : 0.00
## 1st Qu.: 2.0 1st Qu.: 0 1st Qu.: 29.00
## Median : 83.7 Median : 0 Median : 36.00
## Mean : 139.1 Mean : 0 Mean : 34.72
## 3rd Qu.: 350.0 3rd Qu.: 0 3rd Qu.: 41.00
## Max. : 360.0 Max. : 0 Max. : 108.00
## NA's :19216 NA's :19300
## var_accel_forearm avg_roll_forearm stddev_roll_forearm
## Min. : 0.000 Min. : -177.234 Min. : 0.000
## 1st Qu.: 6.759 1st Qu.: -0.909 1st Qu.: 0.428
## Median : 21.165 Median : 11.172 Median : 8.030
## Mean : 33.502 Mean : 33.165 Mean : 41.986
## 3rd Qu.: 51.240 3rd Qu.: 107.132 3rd Qu.: 85.373
## Max. : 172.606 Max. : 177.256 Max. : 179.171
## NA's :19216 NA's :19216 NA's :19216

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## var_roll_forearm avg_pitch_forearm stddev_pitch_forearm
## Min. : 0.00 Min. : -68.17 Min. : 0.000
## 1st Qu.: 0.18 1st Qu.: 0.00 1st Qu.: 0.336
## Median : 64.48 Median : 12.02 Median : 5.516
## Mean : 5274.10 Mean : 11.79 Mean : 7.977
## 3rd Qu.: 7289.08 3rd Qu.: 28.48 3rd Qu.: 12.866
## Max. : 32102.24 Max. : 72.09 Max. : 47.745
## NA's :19216 NA's :19216 NA's :19216
## var_pitch_forearm avg_yaw_forearm stddev_yaw_forearm
## Min. : 0.000 Min. : -155.06 Min. : 0.000
## 1st Qu.: 0.113 1st Qu.: -26.26 1st Qu.: 0.524
## Median : 30.425 Median : 0.00 Median : 24.743
## Mean : 139.593 Mean : 18.00 Mean : 44.854
## 3rd Qu.: 165.532 3rd Qu.: 85.79 3rd Qu.: 85.817
## Max. : 2279.617 Max. : 169.24 Max. : 197.508
## NA's :19216 NA's :19216 NA's :19216
## var_yaw_forearm gyros_forearm_x gyros_forearm_y
## Min. : 0.00 Min. : -22.000 Min. : -7.02000
## 1st Qu.: 0.27 1st Qu.: -0.220 1st Qu.: -1.46000
## Median : 612.21 Median : 0.050 Median : 0.03000
## Mean : 4639.85 Mean : 0.158 Mean : 0.07517
## 3rd Qu.: 7368.41 3rd Qu.: 0.560 3rd Qu.: 1.62000
## Max. : 39009.33 Max. : 3.970 Max. : 311.00000
## NA's :19216
## gyros_forearm_z accel_forearm_x accel_forearm_y accel_forearm_z
## Min. : -8.0900 Min. : -498.00 Min. : -632.0 Min. : -446.00
## 1st Qu.: -0.1800 1st Qu.: -178.00 1st Qu.: 57.0 1st Qu.: -182.00
## Median : 0.0800 Median : -57.00 Median : 201.0 Median : -39.00
## Mean : 0.1512 Mean : -61.65 Mean : 163.7 Mean : -55.29
## 3rd Qu.: 0.4900 3rd Qu.: 76.00 3rd Qu.: 312.0 3rd Qu.: 26.00
## Max. : 231.0000 Max. : 477.00 Max. : 923.0 Max. : 291.00
##
## magnet_forearm_x magnet_forearm_y magnet_forearm_z classe
## Min. : -1280.0 Min. : -896.0 Min. : -973.0 A:5580
## 1st Qu.: -616.0 1st Qu.: 2.0 1st Qu.: 191.0 B:3797
## Median : -378.0 Median : 591.0 Median : 511.0 C:3422
## Mean : -312.6 Mean : 380.1 Mean : 393.6 D:3216
## 3rd Qu.: -73.0 3rd Qu.: 737.0 3rd Qu.: 653.0 E:3607
## Max. : 672.0 Max. : 1480.0 Max. : 1090.0
##

```

[summary\(testdata\)](#)

```

## X.1 X user_name raw_timestamp_part_1
## Min. : 1.00 Min. : 1.00 adelmo :1 Min. :1.322e+09
## 1st Qu.: 5.75 1st Qu.: 5.75 carlitos:3 1st Qu.:1.323e+09
## Median :10.50 Median :10.50 charles :1 Median :1.323e+09
## Mean :10.50 Mean :10.50 eurico :4 Mean :1.323e+09
## 3rd Qu.:15.25 3rd Qu.:15.25 jeremy :8 3rd Qu.:1.323e+09
## Max. :20.00 Max. :20.00 pedro :3 Max. :1.323e+09
##
## raw_timestamp_part_2 cvtd_timestamp new_window num_window
## Min. : 36553 30/11/2011 17:11:4 no:20 Min. : 48.0
## 1st Qu.:268655 05/12/2011 11:24:3 1st Qu.:250.0
## Median :530706 30/11/2011 17:12:3 Median :384.5

```

```

## Mean      :512167      05/12/2011 14:23:2      Mean      :379.6
## 3rd Qu.:787738      28/11/2011 14:14:2      3rd Qu.:467.0
## Max.      :920315      02/12/2011 13:33:1      Max.      :859.0
##          (Other)      :5
## roll_belt      pitch_belt      yaw_belt      total_accel_belt
## Min.      : -5.9200      Min.      :-41.600      Min.      : -93.70      Min.      : 2.00
## 1st Qu.: 0.9075      1st Qu.: 3.013      1st Qu.: -88.62      1st Qu.: 3.00
## Median : 1.1100      Median : 4.655      Median : -87.85      Median : 4.00
## Mean      : 31.3055      Mean      : 5.824      Mean      : -59.30      Mean      : 7.55
## 3rd Qu.: 32.5050      3rd Qu.: 6.135      3rd Qu.: -63.50      3rd Qu.: 8.00
## Max.      :129.0000      Max.      : 27.800      Max.      :162.00      Max.      :21.00
##
## kurtosis_roll_belt kurtosis_pitch_belt kurtosis_yaw_belt
## Mode:logical      Mode:logical      Mode:logical
## NA's:20      NA's:20      NA's:20
##
##
##
##
## skewness_roll_belt skewness_roll_belt.1 skewness_yaw_belt max_roll_belt
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20      NA's:20      NA's:20      NA's:20
##
##
##
##
## max_pitch_belt max_yaw_belt      min_roll_belt      min_pitch_belt
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20      NA's:20      NA's:20      NA's:20
##
##
##
##
## min_yaw_belt      amplitude_roll_belt amplitude_pitch_belt
## Mode:logical      Mode:logical      Mode:logical
## NA's:20      NA's:20      NA's:20
##
##
##
##
## amplitude_yaw_belt var_total_accel_belt avg_roll_belt      stddev_roll_belt
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20      NA's:20      NA's:20      NA's:20
##
##
##
##
## var_roll_belt      avg_pitch_belt      stddev_pitch_belt var_pitch_belt
## Mode:logical      Mode:logical      Mode:logical      Mode:logical

```

```

## NA's:20      NA's:20      NA's:20      NA's:20
##
##
##
##
## avg_yaw_belt   stddev_yaw_belt var_yaw_belt   gyros_belt_x
## Mode:logical  Mode:logical   Mode:logical  Min.    :-0.500
## NA's:20       NA's:20       NA's:20       1st Qu.: -0.070
##                                     Median :  0.020
##                                     Mean    :-0.045
##                                     3rd Qu.:  0.070
##                                     Max.    :  0.240
##
## gyros_belt_y   gyros_belt_z   accel_belt_x   accel_belt_y
## Min.    :-0.050  Min.    :-0.4800  Min.    :-48.00  Min.    :-16.00
## 1st Qu.: -0.005  1st Qu.: -0.1375  1st Qu.: -19.00  1st Qu.:  2.00
## Median :  0.000  Median : -0.0250  Median : -13.00  Median :  4.50
## Mean    :  0.010  Mean    :-0.1005  Mean    :-13.50  Mean    : 18.35
## 3rd Qu.:  0.020  3rd Qu.:  0.0000  3rd Qu.:  -8.75  3rd Qu.: 25.50
## Max.    :  0.110  Max.    :  0.0500  Max.    : 46.00  Max.    : 72.00
##
## accel_belt_z   magnet_belt_x   magnet_belt_y   magnet_belt_z
## Min.    :-187.00  Min.    :-13.00  Min.    :566.0  Min.    :-426.0
## 1st Qu.: -24.00  1st Qu.:  5.50  1st Qu.:578.5  1st Qu.: -398.5
## Median :  27.00  Median : 33.50  Median :600.5  Median : -313.5
## Mean    : -17.60  Mean    : 35.15  Mean    :601.5  Mean    : -346.9
## 3rd Qu.:  38.25  3rd Qu.: 46.25  3rd Qu.:631.2  3rd Qu.: -305.0
## Max.    :  49.00  Max.    :169.00  Max.    :638.0  Max.    : -291.0
##
## roll_arm       pitch_arm       yaw_arm       total_accel_arm
## Min.    :-137.00  Min.    :-63.800  Min.    :-167.00  Min.    :  3.00
## 1st Qu.:  0.00  1st Qu.: -9.188  1st Qu.: -60.15  1st Qu.:20.25
## Median :  0.00  Median :  0.000  Median :  0.00  Median :29.50
## Mean    : 16.42  Mean    : -3.950  Mean    : -2.80  Mean    :26.40
## 3rd Qu.: 71.53  3rd Qu.:  3.465  3rd Qu.: 25.50  3rd Qu.:33.25
## Max.    :152.00  Max.    : 55.000  Max.    :178.00  Max.    :44.00
##
## var_accel_arm  avg_roll_arm   stddev_roll_arm var_roll_arm
## Mode:logical  Mode:logical   Mode:logical   Mode:logical
## NA's:20       NA's:20       NA's:20       NA's:20
##
##
##
##
## avg_pitch_arm  stddev_pitch_arm var_pitch_arm  avg_yaw_arm
## Mode:logical  Mode:logical   Mode:logical   Mode:logical
## NA's:20       NA's:20       NA's:20       NA's:20
##
##
##
##
##

```

```

## stddev_yaw_arm var_yaw_arm      gyros_arm_x      gyros_arm_y
## Mode:logical   Mode:logical   Min.      :-3.710   Min.      :-2.0900
## NA's:20        NA's:20        1st Qu.: -0.645   1st Qu.: -0.6350
##               Median : 0.020   Median : -0.0400
##               Mean   : 0.077   Mean   : -0.1595
##               3rd Qu.: 1.248   3rd Qu.: 0.2175
##               Max.    : 3.660   Max.    : 1.8500
##
## gyros_arm_z      accel_arm_x      accel_arm_y      accel_arm_z
## Min.      :-0.6900   Min.      :-341.0   Min.      :-65.00   Min.      :-404.00
## 1st Qu.: -0.1800   1st Qu.: -277.0   1st Qu.: 52.25    1st Qu.: -128.50
## Median : -0.0250   Median : -194.5   Median : 112.00    Median : -83.50
## Mean   : 0.1205   Mean   : -134.6   Mean   : 103.10    Mean   : -87.85
## 3rd Qu.: 0.5650   3rd Qu.: 5.5     3rd Qu.: 168.25    3rd Qu.: -27.25
## Max.    : 1.1300   Max.    : 106.0    Max.    : 245.00    Max.    : 93.00
##
## magnet_arm_x      magnet_arm_y      magnet_arm_z      kurtosis_roll_arm
## Min.      :-428.00   Min.      :-307.0   Min.      :-499.0   Mode:logical
## 1st Qu.: -373.75   1st Qu.: 205.2     1st Qu.: 403.0     NA's:20
## Median : -265.00   Median : 291.0     Median : 476.5
## Mean   : -38.95   Mean   : 239.4     Mean   : 369.8
## 3rd Qu.: 250.50   3rd Qu.: 358.8     3rd Qu.: 517.0
## Max.    : 750.00   Max.    : 474.0     Max.    : 633.0
##
## kurtosis_picth_arm kurtosis_yaw_arm skewness_roll_arm skewness_pitch_arm
## Mode:logical       Mode:logical       Mode:logical       Mode:logical
## NA's:20             NA's:20             NA's:20             NA's:20
##
##
##
##
##
## skewness_yaw_arm max_roll_arm      max_picth_arm      max_yaw_arm
## Mode:logical       Mode:logical       Mode:logical       Mode:logical
## NA's:20             NA's:20             NA's:20             NA's:20
##
##
##
##
##
## min_roll_arm      min_pitch_arm      min_yaw_arm      amplitude_roll_arm
## Mode:logical       Mode:logical       Mode:logical       Mode:logical
## NA's:20             NA's:20             NA's:20             NA's:20
##
##
##
##
##
## amplitude_pitch_arm amplitude_yaw_arm roll_dumbbell      pitch_dumbbell
## Mode:logical       Mode:logical       Min.      :-111.118   Min.      :-54.97
## NA's:20             NA's:20             1st Qu.: 7.494     1st Qu.: -51.89
##               Median : 50.403   Median : -40.81
##               Mean   : 33.760   Mean   : -19.47
##               3rd Qu.: 58.129   3rd Qu.: 16.12

```

```

##                                     Max.      : 123.984   Max.      : 96.87
##
##   yaw_dumbbell      kurtosis_roll_dumbbell kurtosis_pitch_dumbbell
##   Min.      :-103.3200   Mode:logical      Mode:logical
##   1st Qu.: -75.2809   NA's:20      NA's:20
##   Median :  -8.2863
##   Mean      :  -0.9385
##   3rd Qu.:  55.8335
##   Max.      : 132.2337
##
##   kurtosis_yaw_dumbbell skewness_roll_dumbbell skewness_pitch_dumbbell
##   Mode:logical      Mode:logical      Mode:logical
##   NA's:20      NA's:20      NA's:20
##
##
##
##
##   skewness_yaw_dumbbell max_roll_dumbbell max_pitch_dumbbell
##   Mode:logical      Mode:logical      Mode:logical
##   NA's:20      NA's:20      NA's:20
##
##
##
##
##   max_yaw_dumbbell min_roll_dumbbell min_pitch_dumbbell min_yaw_dumbbell
##   Mode:logical      Mode:logical      Mode:logical      Mode:logical
##   NA's:20      NA's:20      NA's:20      NA's:20
##
##
##
##
##   amplitude_roll_dumbbell amplitude_pitch_dumbbell amplitude_yaw_dumbbell
##   Mode:logical      Mode:logical      Mode:logical
##   NA's:20      NA's:20      NA's:20
##
##
##
##
##   total_accel_dumbbell var_accel_dumbbell avg_roll_dumbbell
##   Min.      : 1.0      Mode:logical      Mode:logical
##   1st Qu.:  7.0      NA's:20      NA's:20
##   Median :15.5
##   Mean      :17.2
##   3rd Qu.:29.0
##   Max.      :31.0
##
##   stddev_roll_dumbbell var_roll_dumbbell avg_pitch_dumbbell
##   Mode:logical      Mode:logical      Mode:logical
##   NA's:20      NA's:20      NA's:20
##
##

```

```

##
##
##
##
## stddev_pitch_dumbbell var_pitch_dumbbell avg_yaw_dumbbell
## Mode:logical          Mode:logical          Mode:logical
## NA's:20                NA's:20                NA's:20
##
##
##
##
##
## stddev_yaw_dumbbell var_yaw_dumbbell gyros_dumbbell_x gyros_dumbbell_y
## Mode:logical          Mode:logical          Min.      :-1.0300 Min.      :-1.1100
## NA's:20                NA's:20                1st Qu.: 0.1600 1st Qu.: -0.2100
##                               Median : 0.3600 Median : 0.0150
##                               Mean   : 0.2690 Mean   : 0.0605
##                               3rd Qu.: 0.4625 3rd Qu.: 0.1450
##                               Max.   : 1.0600 Max.   : 1.9100
##
## gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y accel_dumbbell_z
## Min.      :-1.180 Min.      :-159.00 Min.      :-30.00 Min.      :-221.0
## 1st Qu.: -0.485 1st Qu.: -140.25 1st Qu.: 5.75 1st Qu.: -192.2
## Median : -0.280 Median : -19.00 Median : 71.50 Median : -3.0
## Mean   : -0.266 Mean   : -47.60 Mean   : 70.55 Mean   : -60.0
## 3rd Qu.: -0.165 3rd Qu.: 15.75 3rd Qu.: 151.25 3rd Qu.: 76.5
## Max.   : 1.100 Max.   : 185.00 Max.   : 166.00 Max.   : 100.0
##
## magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z roll_forearm
## Min.      :-576.0 Min.      :-558.0 Min.      :-164.00 Min.      :-176.00
## 1st Qu.: -528.0 1st Qu.: 259.5 1st Qu.: -33.00 1st Qu.: -40.25
## Median : -508.5 Median : 316.0 Median : 49.50 Median : 94.20
## Mean   : -304.2 Mean   : 189.3 Mean   : 71.40 Mean   : 38.66
## 3rd Qu.: -317.0 3rd Qu.: 348.2 3rd Qu.: 96.25 3rd Qu.: 143.25
## Max.   : 523.0 Max.   : 403.0 Max.   : 368.00 Max.   : 176.00
##
## pitch_forearm yaw_forearm kurtosis_roll_forearm
## Min.      :-63.500 Min.      :-168.000 Mode:logical
## 1st Qu.: -11.457 1st Qu.: -93.375 NA's:20
## Median : 8.830 Median : -19.250
## Mean   : 7.099 Mean   : 2.195
## 3rd Qu.: 28.500 3rd Qu.: 104.500
## Max.   : 59.300 Max.   : 159.000
##
## kurtosis_pitch_forearm kurtosis_yaw_forearm skewness_roll_forearm
## Mode:logical          Mode:logical          Mode:logical
## NA's:20                NA's:20                NA's:20
##
##
##
##
## skewness_pitch_forearm skewness_yaw_forearm max_roll_forearm
## Mode:logical          Mode:logical          Mode:logical

```

```

## NA's:20          NA's:20          NA's:20
##
##
##
##
## max_pitch_forearm max_yaw_forearm min_roll_forearm min_pitch_forearm
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20           NA's:20
##
##
##
##
## min_yaw_forearm amplitude_roll_forearm amplitude_pitch_forearm
## Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20
##
##
##
##
## amplitude_yaw_forearm total_accel_forearm var_accel_forearm
## Mode:logical      Min.      :21.00      Mode:logical
## NA's:20           1st Qu.:24.00      NA's:20
##                   Median :32.50
##                   Mean   :32.05
##                   3rd Qu.:36.75
##                   Max.   :47.00
##
## avg_roll_forearm stddev_roll_forearm var_roll_forearm avg_pitch_forearm
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20           NA's:20
##
##
##
##
## stddev_pitch_forearm var_pitch_forearm avg_yaw_forearm stddev_yaw_forearm
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20           NA's:20
##
##
##
##
## var_yaw_forearm gyros_forearm_x gyros_forearm_y gyros_forearm_z
## Mode:logical      Min.      : -1.0600 Min.      : -5.9700 Min.      : -1.2600
## NA's:20           1st Qu.: -0.5850 1st Qu.: -1.2875 1st Qu.: -0.0975
##                   Median : 0.0200 Median : 0.0350 Median : 0.2300
##                   Mean   : -0.0200 Mean   : -0.0415 Mean   : 0.2610
##                   3rd Qu.: 0.2925 3rd Qu.: 2.0475 3rd Qu.: 0.7625
##                   Max.    : 1.3800 Max.    : 4.2600 Max.    : 1.8000
##

```

```
## accel_forearm_x accel_forearm_y accel_forearm_z magnet_forearm_x
## Min. : -212.0 Min. : -331.0 Min. : -282.0 Min. : -714.0
## 1st Qu.: -114.8 1st Qu.: 8.5 1st Qu.: -199.0 1st Qu.: -427.2
## Median : 86.0 Median : 138.0 Median : -148.5 Median : -189.5
## Mean : 38.8 Mean : 125.3 Mean : -93.7 Mean : -159.2
## 3rd Qu.: 166.2 3rd Qu.: 268.0 3rd Qu.: -31.0 3rd Qu.: 41.5
## Max. : 232.0 Max. : 406.0 Max. : 179.0 Max. : 532.0
##
## magnet_forearm_y magnet_forearm_z problem_id
## Min. : -787.0 Min. : -32.0 Min. : 1.00
## 1st Qu.: -328.8 1st Qu.: 275.2 1st Qu.: 5.75
## Median : 487.0 Median : 491.5 Median : 10.50
## Mean : 191.8 Mean : 460.2 Mean : 10.50
## 3rd Qu.: 720.8 3rd Qu.: 661.5 3rd Qu.: 15.25
## Max. : 800.0 Max. : 884.0 Max. : 20.00
##
```

```
# The summary results revealed that some columns contains all "NA". So deleted columns with all missing
traindataset<-traindata[,colSums(is.na(traindata)) == 0]
testdataset <-testdata[,colSums(is.na(testdata)) == 0]
# summary of training and test data after removal of NAs
summary(traindataset)
```

```
## X.1 X user_name raw_timestamp_part_1
## Min. : 1 Min. : 1 adelmo :3892 Min. :1.322e+09
## 1st Qu.: 4906 1st Qu.: 4906 carlitos:3112 1st Qu.:1.323e+09
## Median : 9812 Median : 9812 charles :3536 Median :1.323e+09
## Mean : 9812 Mean : 9812 eurico :3070 Mean :1.323e+09
## 3rd Qu.:14717 3rd Qu.:14717 jeremy :3402 3rd Qu.:1.323e+09
## Max. :19622 Max. :19622 pedro :2610 Max. :1.323e+09
##
## raw_timestamp_part_2 cvtd_timestamp new_window num_window
## Min. : 294 28/11/2011 14:14: 1498 no :19216 Min. : 1.0
## 1st Qu.:252912 05/12/2011 11:24: 1497 yes: 406 1st Qu.:222.0
## Median :496380 30/11/2011 17:11: 1440 Median :424.0
## Mean :500656 05/12/2011 11:25: 1425 Mean :430.6
## 3rd Qu.:751891 02/12/2011 14:57: 1380 3rd Qu.:644.0
## Max. :998801 02/12/2011 13:34: 1375 Max. :864.0
## (Other) :11007
## roll_belt pitch_belt yaw_belt total_accel_belt
## Min. : -28.90 Min. : -55.8000 Min. : -180.00 Min. : 0.00
## 1st Qu.: 1.10 1st Qu.: 1.7600 1st Qu.: -88.30 1st Qu.: 3.00
## Median :113.00 Median : 5.2800 Median : -13.00 Median :17.00
## Mean : 64.41 Mean : 0.3053 Mean : -11.21 Mean :11.31
## 3rd Qu.:123.00 3rd Qu.: 14.9000 3rd Qu.: 12.90 3rd Qu.:18.00
## Max. :162.00 Max. : 60.3000 Max. : 179.00 Max. :29.00
##
## gyros_belt_x gyros_belt_y gyros_belt_z
## Min. : -1.040000 Min. : -0.64000 Min. : -1.4600
## 1st Qu.: -0.030000 1st Qu.: 0.00000 1st Qu.: -0.2000
## Median : 0.030000 Median : 0.02000 Median : -0.1000
## Mean : -0.005592 Mean : 0.03959 Mean : -0.1305
## 3rd Qu.: 0.110000 3rd Qu.: 0.11000 3rd Qu.: -0.0200
## Max. : 2.220000 Max. : 0.64000 Max. : 1.6200
##
```

```

## accel_belt_x      accel_belt_y      accel_belt_z      magnet_belt_x
## Min.      :-120.000  Min.      :-69.00  Min.      :-275.00  Min.      :-52.0
## 1st Qu.: -21.000  1st Qu.:  3.00  1st Qu.: -162.00  1st Qu.:  9.0
## Median : -15.000  Median : 35.00  Median : -152.00  Median : 35.0
## Mean   :  -5.595  Mean   : 30.15  Mean   : -72.59  Mean   : 55.6
## 3rd Qu.: -5.000  3rd Qu.: 61.00  3rd Qu.:  27.00  3rd Qu.: 59.0
## Max.    :  85.000  Max.    :164.00  Max.    : 105.00  Max.    :485.0
##
## magnet_belt_y      magnet_belt_z      roll_arm      pitch_arm
## Min.      :354.0  Min.      :-623.0  Min.      :-180.00  Min.      :-88.800
## 1st Qu.:581.0  1st Qu.: -375.0  1st Qu.: -31.77  1st Qu.: -25.900
## Median :601.0  Median : -320.0  Median :  0.00  Median :  0.000
## Mean   :593.7  Mean   : -345.5  Mean   : 17.83  Mean   : -4.612
## 3rd Qu.:610.0  3rd Qu.: -306.0  3rd Qu.: 77.30  3rd Qu.: 11.200
## Max.    :673.0  Max.    : 293.0  Max.    : 180.00  Max.    : 88.500
##
## yaw_arm      total_accel_arm      gyros_arm_x      gyros_arm_y
## Min.      :-180.0000  Min.      : 1.00  Min.      :-6.37000  Min.      :-3.4400
## 1st Qu.: -43.1000  1st Qu.:17.00  1st Qu.: -1.33000  1st Qu.: -0.8000
## Median :  0.0000  Median :27.00  Median : 0.08000  Median : -0.2400
## Mean   :  -0.6188  Mean   :25.51  Mean   : 0.04277  Mean   : -0.2571
## 3rd Qu.:  45.8750  3rd Qu.:33.00  3rd Qu.: 1.57000  3rd Qu.: 0.1400
## Max.    : 180.0000  Max.    :66.00  Max.    : 4.87000  Max.    : 2.8400
##
## gyros_arm_z      accel_arm_x      accel_arm_y      accel_arm_z
## Min.      :-2.3300  Min.      :-404.00  Min.      :-318.0  Min.      :-636.00
## 1st Qu.: -0.0700  1st Qu.: -242.00  1st Qu.: -54.0  1st Qu.: -143.00
## Median : 0.2300  Median : -44.00  Median : 14.0  Median : -47.00
## Mean   : 0.2695  Mean   : -60.24  Mean   : 32.6  Mean   : -71.25
## 3rd Qu.: 0.7200  3rd Qu.: 84.00  3rd Qu.: 139.0  3rd Qu.: 23.00
## Max.    : 3.0200  Max.    : 437.00  Max.    : 308.0  Max.    : 292.00
##
## magnet_arm_x      magnet_arm_y      magnet_arm_z      roll_dumbbell
## Min.      :-584.0  Min.      :-392.0  Min.      :-597.0  Min.      :-153.71
## 1st Qu.: -300.0  1st Qu.:  -9.0  1st Qu.: 131.2  1st Qu.: -18.49
## Median : 289.0  Median : 202.0  Median : 444.0  Median : 48.17
## Mean   : 191.7  Mean   : 156.6  Mean   : 306.5  Mean   : 23.84
## 3rd Qu.: 637.0  3rd Qu.: 323.0  3rd Qu.: 545.0  3rd Qu.: 67.61
## Max.    : 782.0  Max.    : 583.0  Max.    : 694.0  Max.    : 153.55
##
## pitch_dumbbell      yaw_dumbbell      total_accel_dumbbell
## Min.      :-149.59  Min.      :-150.871  Min.      : 0.00
## 1st Qu.: -40.89  1st Qu.: -77.644  1st Qu.: 4.00
## Median : -20.96  Median : -3.324  Median :10.00
## Mean   : -10.78  Mean   :  1.674  Mean   :13.72
## 3rd Qu.: 17.50  3rd Qu.: 79.643  3rd Qu.:19.00
## Max.    : 149.40  Max.    : 154.952  Max.    :58.00
##
## gyros_dumbbell_x      gyros_dumbbell_y      gyros_dumbbell_z
## Min.      :-204.0000  Min.      :-2.10000  Min.      : -2.380
## 1st Qu.: -0.0300  1st Qu.: -0.14000  1st Qu.: -0.310
## Median :  0.1300  Median : 0.03000  Median : -0.130
## Mean   :  0.1611  Mean   : 0.04606  Mean   : -0.129
## 3rd Qu.:  0.3500  3rd Qu.: 0.21000  3rd Qu.:  0.030

```

```

## Max.      : 2.2200   Max.      :52.00000   Max.      :317.000
##
## accel_dumbbell_x accel_dumbbell_y accel_dumbbell_z magnet_dumbbell_x
## Min.      : -419.00   Min.      : -189.00   Min.      : -334.00   Min.      : -643.0
## 1st Qu.: -50.00   1st Qu.:  -8.00   1st Qu.: -142.00   1st Qu.: -535.0
## Median :  -8.00   Median :  41.50   Median :  -1.00   Median : -479.0
## Mean      : -28.62   Mean      :  52.63   Mean      : -38.32   Mean      : -328.5
## 3rd Qu.:  11.00   3rd Qu.: 111.00   3rd Qu.:  38.00   3rd Qu.: -304.0
## Max.      : 235.00   Max.      : 315.00   Max.      : 318.00   Max.      : 592.0
##
## magnet_dumbbell_y magnet_dumbbell_z roll_forearm pitch_forearm
## Min.      : -3600   Min.      : -262.00   Min.      : -180.0000   Min.      : -72.50
## 1st Qu.:  231     1st Qu.: -45.00   1st Qu.:  -0.7375   1st Qu.:  0.00
## Median :  311     Median :  13.00   Median :  21.7000   Median :  9.24
## Mean      :  221     Mean      :  46.05   Mean      :  33.8265   Mean      : 10.71
## 3rd Qu.:  390     3rd Qu.:  95.00   3rd Qu.: 140.0000   3rd Qu.: 28.40
## Max.      :  633     Max.      : 452.00   Max.      : 180.0000   Max.      : 89.80
##
## yaw_forearm total_accel_forearm gyros_forearm_x
## Min.      : -180.00   Min.      :  0.00   Min.      : -22.000
## 1st Qu.: -68.60   1st Qu.: 29.00   1st Qu.: -0.220
## Median :  0.00   Median : 36.00   Median :  0.050
## Mean      :  19.21   Mean      : 34.72   Mean      :  0.158
## 3rd Qu.: 110.00   3rd Qu.: 41.00   3rd Qu.:  0.560
## Max.      : 180.00   Max.      :108.00   Max.      :  3.970
##
## gyros_forearm_y gyros_forearm_z accel_forearm_x accel_forearm_y
## Min.      : -7.02000   Min.      : -8.0900   Min.      : -498.00   Min.      : -632.0
## 1st Qu.: -1.46000   1st Qu.: -0.1800   1st Qu.: -178.00   1st Qu.:  57.0
## Median :  0.03000   Median :  0.0800   Median :  -57.00   Median : 201.0
## Mean      :  0.07517   Mean      :  0.1512   Mean      : -61.65   Mean      : 163.7
## 3rd Qu.:  1.62000   3rd Qu.:  0.4900   3rd Qu.:  76.00   3rd Qu.: 312.0
## Max.      :311.00000   Max.      :231.0000   Max.      : 477.00   Max.      : 923.0
##
## accel_forearm_z magnet_forearm_x magnet_forearm_y magnet_forearm_z
## Min.      : -446.00   Min.      : -1280.0   Min.      : -896.0   Min.      : -973.0
## 1st Qu.: -182.00   1st Qu.: -616.0   1st Qu.:  2.0   1st Qu.: 191.0
## Median : -39.00   Median : -378.0   Median : 591.0   Median : 511.0
## Mean      : -55.29   Mean      : -312.6   Mean      : 380.1   Mean      : 393.6
## 3rd Qu.:  26.00   3rd Qu.: -73.0   3rd Qu.: 737.0   3rd Qu.: 653.0
## Max.      : 291.00   Max.      :  672.0   Max.      :1480.0   Max.      :1090.0
##
## classe
## A:5580
## B:3797
## C:3422
## D:3216
## E:3607
##
##

```

```
summary(testdataset)
```

```

##      X.1      X      user_name raw_timestamp_part_1
## Min.   : 1.00   Min.   : 1.00   adelmo :1      Min.   :1.322e+09

```

```

## 1st Qu.: 5.75    1st Qu.: 5.75    carlitos:3    1st Qu.:1.323e+09
## Median :10.50   Median :10.50   charles :1    Median :1.323e+09
## Mean   :10.50   Mean   :10.50   eurico  :4    Mean   :1.323e+09
## 3rd Qu.:15.25   3rd Qu.:15.25   jeremy  :8    3rd Qu.:1.323e+09
## Max.    :20.00   Max.    :20.00   pedro   :3    Max.    :1.323e+09
##
## raw_timestamp_part_2    cvtd_timestamp new_window    num_window
## Min.    : 36553        30/11/2011 17:11:4    no:20        Min.    : 48.0
## 1st Qu.:268655        05/12/2011 11:24:3                1st Qu.:250.0
## Median :530706        30/11/2011 17:12:3                Median :384.5
## Mean   :512167        05/12/2011 14:23:2                Mean   :379.6
## 3rd Qu.:787738        28/11/2011 14:14:2                3rd Qu.:467.0
## Max.    :920315        02/12/2011 13:33:1                Max.    :859.0
## (Other)                :5
## roll_belt              pitch_belt              yaw_belt              total_accel_belt
## Min.    : -5.9200    Min.    : -41.600    Min.    : -93.70    Min.    : 2.00
## 1st Qu.: 0.9075    1st Qu.: 3.013    1st Qu.: -88.62    1st Qu.: 3.00
## Median : 1.1100    Median : 4.655    Median : -87.85    Median : 4.00
## Mean   : 31.3055    Mean   : 5.824    Mean   : -59.30    Mean   : 7.55
## 3rd Qu.: 32.5050    3rd Qu.: 6.135    3rd Qu.: -63.50    3rd Qu.: 8.00
## Max.    :129.0000    Max.    : 27.800    Max.    :162.00    Max.    :21.00
##
## gyros_belt_x          gyros_belt_y          gyros_belt_z          accel_belt_x
## Min.    : -0.500    Min.    : -0.050    Min.    : -0.4800    Min.    : -48.00
## 1st Qu.: -0.070    1st Qu.: -0.005    1st Qu.: -0.1375    1st Qu.: -19.00
## Median : 0.020    Median : 0.000    Median : -0.0250    Median : -13.00
## Mean   : -0.045    Mean   : 0.010    Mean   : -0.1005    Mean   : -13.50
## 3rd Qu.: 0.070    3rd Qu.: 0.020    3rd Qu.: 0.0000    3rd Qu.: -8.75
## Max.    : 0.240    Max.    : 0.110    Max.    : 0.0500    Max.    : 46.00
##
## accel_belt_y          accel_belt_z          magnet_belt_x          magnet_belt_y
## Min.    : -16.00    Min.    : -187.00    Min.    : -13.00    Min.    :566.0
## 1st Qu.: 2.00    1st Qu.: -24.00    1st Qu.: 5.50    1st Qu.:578.5
## Median : 4.50    Median : 27.00    Median : 33.50    Median :600.5
## Mean   : 18.35    Mean   : -17.60    Mean   : 35.15    Mean   :601.5
## 3rd Qu.: 25.50    3rd Qu.: 38.25    3rd Qu.: 46.25    3rd Qu.:631.2
## Max.    : 72.00    Max.    : 49.00    Max.    :169.00    Max.    :638.0
##
## magnet_belt_z          roll_arm              pitch_arm              yaw_arm
## Min.    : -426.0    Min.    : -137.00    Min.    : -63.800    Min.    : -167.00
## 1st Qu.: -398.5    1st Qu.: 0.00    1st Qu.: -9.188    1st Qu.: -60.15
## Median : -313.5    Median : 0.00    Median : 0.000    Median : 0.00
## Mean   : -346.9    Mean   : 16.42    Mean   : -3.950    Mean   : -2.80
## 3rd Qu.: -305.0    3rd Qu.: 71.53    3rd Qu.: 3.465    3rd Qu.: 25.50
## Max.    : -291.0    Max.    : 152.00    Max.    : 55.000    Max.    : 178.00
##
## total_accel_arm        gyros_arm_x          gyros_arm_y          gyros_arm_z
## Min.    : 3.00    Min.    : -3.710    Min.    : -2.0900    Min.    : -0.6900
## 1st Qu.:20.25    1st Qu.: -0.645    1st Qu.: -0.6350    1st Qu.: -0.1800
## Median :29.50    Median : 0.020    Median : -0.0400    Median : -0.0250
## Mean   :26.40    Mean   : 0.077    Mean   : -0.1595    Mean   : 0.1205
## 3rd Qu.:33.25    3rd Qu.: 1.248    3rd Qu.: 0.2175    3rd Qu.: 0.5650
## Max.    :44.00    Max.    : 3.660    Max.    : 1.8500    Max.    : 1.1300
##

```

```

## accel_arm_x accel_arm_y accel_arm_z magnet_arm_x
## Min. :-341.0 Min. :-65.00 Min. :-404.00 Min. :-428.00
## 1st Qu.: -277.0 1st Qu.: 52.25 1st Qu.: -128.50 1st Qu.: -373.75
## Median : -194.5 Median : 112.00 Median : -83.50 Median : -265.00
## Mean :-134.6 Mean : 103.10 Mean : -87.85 Mean : -38.95
## 3rd Qu.: 5.5 3rd Qu.: 168.25 3rd Qu.: -27.25 3rd Qu.: 250.50
## Max. : 106.0 Max. : 245.00 Max. : 93.00 Max. : 750.00
##
## magnet_arm_y magnet_arm_z roll_dumbbell pitch_dumbbell
## Min. :-307.0 Min. :-499.0 Min. :-111.118 Min. :-54.97
## 1st Qu.: 205.2 1st Qu.: 403.0 1st Qu.: 7.494 1st Qu.: -51.89
## Median : 291.0 Median : 476.5 Median : 50.403 Median : -40.81
## Mean : 239.4 Mean : 369.8 Mean : 33.760 Mean : -19.47
## 3rd Qu.: 358.8 3rd Qu.: 517.0 3rd Qu.: 58.129 3rd Qu.: 16.12
## Max. : 474.0 Max. : 633.0 Max. : 123.984 Max. : 96.87
##
## yaw_dumbbell total_accel_dumbbell gyros_dumbbell_x
## Min. :-103.3200 Min. : 1.0 Min. :-1.0300
## 1st Qu.: -75.2809 1st Qu.: 7.0 1st Qu.: 0.1600
## Median : -8.2863 Median : 15.5 Median : 0.3600
## Mean : -0.9385 Mean : 17.2 Mean : 0.2690
## 3rd Qu.: 55.8335 3rd Qu.: 29.0 3rd Qu.: 0.4625
## Max. : 132.2337 Max. : 31.0 Max. : 1.0600
##
## gyros_dumbbell_y gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y
## Min. :-1.1100 Min. :-1.180 Min. :-159.00 Min. :-30.00
## 1st Qu.: -0.2100 1st Qu.: -0.485 1st Qu.: -140.25 1st Qu.: 5.75
## Median : 0.0150 Median : -0.280 Median : -19.00 Median : 71.50
## Mean : 0.0605 Mean : -0.266 Mean : -47.60 Mean : 70.55
## 3rd Qu.: 0.1450 3rd Qu.: -0.165 3rd Qu.: 15.75 3rd Qu.: 151.25
## Max. : 1.9100 Max. : 1.100 Max. : 185.00 Max. : 166.00
##
## accel_dumbbell_z magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z
## Min. :-221.0 Min. :-576.0 Min. :-558.0 Min. :-164.00
## 1st Qu.: -192.2 1st Qu.: -528.0 1st Qu.: 259.5 1st Qu.: -33.00
## Median : -3.0 Median : -508.5 Median : 316.0 Median : 49.50
## Mean : -60.0 Mean : -304.2 Mean : 189.3 Mean : 71.40
## 3rd Qu.: 76.5 3rd Qu.: -317.0 3rd Qu.: 348.2 3rd Qu.: 96.25
## Max. : 100.0 Max. : 523.0 Max. : 403.0 Max. : 368.00
##
## roll_forearm pitch_forearm yaw_forearm
## Min. :-176.00 Min. :-63.500 Min. :-168.000
## 1st Qu.: -40.25 1st Qu.: -11.457 1st Qu.: -93.375
## Median : 94.20 Median : 8.830 Median : -19.250
## Mean : 38.66 Mean : 7.099 Mean : 2.195
## 3rd Qu.: 143.25 3rd Qu.: 28.500 3rd Qu.: 104.500
## Max. : 176.00 Max. : 59.300 Max. : 159.000
##
## total_accel_forearm gyros_forearm_x gyros_forearm_y gyros_forearm_z
## Min. :21.00 Min. : -1.0600 Min. : -5.9700 Min. : -1.2600
## 1st Qu.: 24.00 1st Qu.: -0.5850 1st Qu.: -1.2875 1st Qu.: -0.0975
## Median : 32.50 Median : 0.0200 Median : 0.0350 Median : 0.2300
## Mean : 32.05 Mean : -0.0200 Mean : -0.0415 Mean : 0.2610
## 3rd Qu.: 36.75 3rd Qu.: 0.2925 3rd Qu.: 2.0475 3rd Qu.: 0.7625

```

```
## Max. :47.00      Max. : 1.3800  Max. : 4.2600  Max. : 1.8000
##
## accel_forearm_x accel_forearm_y accel_forearm_z magnet_forearm_x
## Min. : -212.0  Min. : -331.0  Min. : -282.0  Min. : -714.0
## 1st Qu.: -114.8 1st Qu.: 8.5 1st Qu.: -199.0 1st Qu.: -427.2
## Median : 86.0  Median : 138.0  Median : -148.5  Median : -189.5
## Mean : 38.8  Mean : 125.3  Mean : -93.7  Mean : -159.2
## 3rd Qu.: 166.2 3rd Qu.: 268.0 3rd Qu.: -31.0 3rd Qu.: 41.5
## Max. : 232.0  Max. : 406.0  Max. : 179.0  Max. : 532.0
##
## magnet_forearm_y magnet_forearm_z problem_id
## Min. : -787.0  Min. : -32.0  Min. : 1.00
## 1st Qu.: -328.8 1st Qu.: 275.2 1st Qu.: 5.75
## Median : 487.0  Median : 491.5  Median : 10.50
## Mean : 191.8  Mean : 460.2  Mean : 10.50
## 3rd Qu.: 720.8 3rd Qu.: 661.5 3rd Qu.: 15.25
## Max. : 800.0  Max. : 884.0  Max. : 20.00
##
```

```
#Structure of data
str(traindataset)
```

```
## 'data.frame': 19622 obs. of 61 variables:
## $ X.1 : int 1 2 3 4 5 6 7 8 9 10 ...
## $ X : int 1 2 3 4 5 6 7 8 9 10 ...
## $ user_name : Factor w/ 6 levels "adelmo","carlitos",...: 2 2 2 2 2 2 2 2 2 2 ...
## $ raw_timestamp_part_1: int 1323084231 1323084231 1323084231 1323084232 1323084232 1323084232 1323084232 1323084232 ...
## $ raw_timestamp_part_2: int 788290 808298 820366 120339 196328 304277 368296 440390 484323 484434 ...
## $ cvtd_timestamp : Factor w/ 20 levels "02/12/2011 13:32",...: 9 9 9 9 9 9 9 9 9 9 ...
## $ new_window : Factor w/ 2 levels "no","yes": 1 1 1 1 1 1 1 1 1 1 ...
## $ num_window : int 11 11 11 12 12 12 12 12 12 12 ...
## $ roll_belt : num 1.41 1.41 1.42 1.48 1.48 1.45 1.42 1.42 1.43 1.45 ...
## $ pitch_belt : num 8.07 8.07 8.07 8.05 8.07 8.06 8.09 8.13 8.16 8.17 ...
## $ yaw_belt : num -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 -94.4 ...
## $ total_accel_belt : int 3 3 3 3 3 3 3 3 3 3 ...
## $ gyros_belt_x : num 0 0.02 0 0.02 0.02 0.02 0.02 0.02 0.02 0.03 ...
## $ gyros_belt_y : num 0 0 0 0 0.02 0 0 0 0 0 ...
## $ gyros_belt_z : num -0.02 -0.02 -0.02 -0.03 -0.02 -0.02 -0.02 -0.02 -0.02 0 ...
## $ accel_belt_x : int -21 -22 -20 -22 -21 -21 -22 -22 -20 -21 ...
## $ accel_belt_y : int 4 4 5 3 2 4 3 4 2 4 ...
## $ accel_belt_z : int 22 22 23 21 24 21 21 21 24 22 ...
## $ magnet_belt_x : int -3 -7 -2 -6 -6 0 -4 -2 1 -3 ...
## $ magnet_belt_y : int 599 608 600 604 600 603 599 603 602 609 ...
## $ magnet_belt_z : int -313 -311 -305 -310 -302 -312 -311 -313 -312 -308 ...
## $ roll_arm : num -128 -128 -128 -128 -128 -128 -128 -128 -128 -128 ...
## $ pitch_arm : num 22.5 22.5 22.5 22.1 22.1 22 21.9 21.8 21.7 21.6 ...
## $ yaw_arm : num -161 -161 -161 -161 -161 -161 -161 -161 -161 -161 ...
## $ total_accel_arm : int 34 34 34 34 34 34 34 34 34 34 ...
## $ gyros_arm_x : num 0 0.02 0.02 0.02 0 0.02 0 0.02 0.02 0.02 ...
## $ gyros_arm_y : num 0 -0.02 -0.02 -0.03 -0.03 -0.03 -0.03 -0.02 -0.03 -0.03 ...
## $ gyros_arm_z : num -0.02 -0.02 -0.02 0.02 0 0 0 0 -0.02 -0.02 ...
## $ accel_arm_x : int -288 -290 -289 -289 -289 -289 -289 -289 -288 -288 ...
## $ accel_arm_y : int 109 110 110 111 111 111 111 111 109 110 ...
## $ accel_arm_z : int -123 -125 -126 -123 -123 -122 -125 -124 -122 -124 ...
## $ magnet_arm_x : int -368 -369 -368 -372 -374 -369 -373 -372 -369 -376 ...
```

```
## $ magnet_arm_y      : int  337 337 344 344 337 342 336 338 341 334 ...
## $ magnet_arm_z      : int  516 513 513 512 506 513 509 510 518 516 ...
## $ roll_dumbbell     : num  13.1 13.1 12.9 13.4 13.4 ...
## $ pitch_dumbbell    : num  -70.5 -70.6 -70.3 -70.4 -70.4 ...
## $ yaw_dumbbell      : num  -84.9 -84.7 -85.1 -84.9 -84.9 ...
## $ total_accel_dumbbell: int  37 37 37 37 37 37 37 37 37 37 ...
## $ gyros_dumbbell_x   : num   0 0 0 0 0 0 0 0 0 0 ...
## $ gyros_dumbbell_y   : num  -0.02 -0.02 -0.02 -0.02 -0.02 -0.02 -0.02 -0.02 -0.02 ...
## $ gyros_dumbbell_z   : num   0 0 0 -0.02 0 0 0 0 0 0 ...
## $ accel_dumbbell_x   : int  -234 -233 -232 -232 -233 -234 -232 -234 -232 -235 ...
## $ accel_dumbbell_y   : int   47 47 46 48 48 48 47 46 47 48 ...
## $ accel_dumbbell_z   : int  -271 -269 -270 -269 -270 -269 -270 -272 -269 -270 ...
## $ magnet_dumbbell_x  : int  -559 -555 -561 -552 -554 -558 -551 -555 -549 -558 ...
## $ magnet_dumbbell_y  : int   293 296 298 303 292 294 295 300 292 291 ...
## $ magnet_dumbbell_z  : num  -65 -64 -63 -60 -68 -66 -70 -74 -65 -69 ...
## $ roll_forearm       : num  28.4 28.3 28.3 28.1 28 27.9 27.9 27.8 27.7 27.7 ...
## $ pitch_forearm      : num  -63.9 -63.9 -63.9 -63.9 -63.9 -63.9 -63.9 -63.8 -63.8 -63.8 ...
## $ yaw_forearm        : num  -153 -153 -152 -152 -152 -152 -152 -152 -152 -152 ...
## $ total_accel_forearm: int   36 36 36 36 36 36 36 36 36 36 ...
## $ gyros_forearm_x    : num   0.03 0.02 0.03 0.02 0.02 0.02 0.02 0.02 0.03 0.02 ...
## $ gyros_forearm_y    : num   0 0 -0.02 -0.02 0 -0.02 0 -0.02 0 0 ...
## $ gyros_forearm_z    : num  -0.02 -0.02 0 0 -0.02 -0.03 -0.02 0 -0.02 -0.02 ...
## $ accel_forearm_x    : int  192 192 196 189 189 193 195 193 193 190 ...
## $ accel_forearm_y    : int  203 203 204 206 206 203 205 205 204 205 ...
## $ accel_forearm_z    : int  -215 -216 -213 -214 -214 -215 -215 -213 -214 -215 ...
## $ magnet_forearm_x   : int  -17 -18 -18 -16 -17 -9 -18 -9 -16 -22 ...
## $ magnet_forearm_y   : num  654 661 658 658 655 660 659 660 653 656 ...
## $ magnet_forearm_z   : num  476 473 469 469 473 478 470 474 476 473 ...
## $ classe             : Factor w/ 5 levels "A","B","C","D",...: 1 1 1 1 1 1 1 1 1 1 ...
```

```
str(testdataset)
```

```
## 'data.frame':    20 obs. of  61 variables:
## $ X.1             : int   1 2 3 4 5 6 7 8 9 10 ...
## $ X               : int   1 2 3 4 5 6 7 8 9 10 ...
## $ user_name       : Factor w/ 6 levels "adelmo","carlitos",...: 6 5 5 1 4 5 5 5 2 3 ...
## $ raw_timestamp_part_1: int  1323095002 1322673067 1322673075 1322832789 1322489635 1322673149 1322...
## $ raw_timestamp_part_2: int  868349 778725 342967 560311 814776 510661 766645 54671 916313 384285 ...
## $ cvtd_timestamp    : Factor w/ 11 levels "02/12/2011 13:33",...: 5 10 10 1 6 11 11 10 3 2 ...
## $ new_window        : Factor w/ 1 level "no": 1 1 1 1 1 1 1 1 1 1 ...
## $ num_window        : int   74 431 439 194 235 504 485 440 323 664 ...
## $ roll_belt         : num  123 1.02 0.87 125 1.35 -5.92 1.2 0.43 0.93 114 ...
## $ pitch_belt        : num   27 4.87 1.82 -41.6 3.33 1.59 4.44 4.15 6.72 22.4 ...
## $ yaw_belt          : num  -4.75 -88.9 -88.5 162 -88.6 -87.7 -87.3 -88.5 -93.7 -13.1 ...
## $ total_accel_belt  : int   20 4 5 17 3 4 4 4 4 18 ...
## $ gyros_belt_x       : num  -0.5 -0.06 0.05 0.11 0.03 0.1 -0.06 -0.18 0.1 0.14 ...
## $ gyros_belt_y       : num  -0.02 -0.02 0.02 0.11 0.02 0.05 0 -0.02 0 0.11 ...
## $ gyros_belt_z       : num  -0.46 -0.07 0.03 -0.16 0 -0.13 0 -0.03 -0.02 -0.16 ...
## $ accel_belt_x       : int  -38 -13 1 46 -8 -11 -14 -10 -15 -25 ...
## $ accel_belt_y       : int   69 11 -1 45 4 -16 2 -2 1 63 ...
## $ accel_belt_z       : int  -179 39 49 -156 27 38 35 42 32 -158 ...
## $ magnet_belt_x      : int  -13 43 29 169 33 31 50 39 -6 10 ...
## $ magnet_belt_y      : int  581 636 631 608 566 638 622 635 600 601 ...
## $ magnet_belt_z      : int  -382 -309 -312 -304 -418 -291 -315 -305 -302 -330 ...
## $ roll_arm          : num  40.7 0 0 -109 76.1 0 0 0 -137 -82.4 ...
```

```
## $ pitch_arm      : num -27.8 0 0 55 2.76 0 0 0 11.2 -63.8 ...
## $ yaw_arm        : num 178 0 0 -142 102 0 0 0 -167 -75.3 ...
## $ total_accel_arm : int 10 38 44 25 29 14 15 22 34 32 ...
## $ gyros_arm_x    : num -1.65 -1.17 2.1 0.22 -1.96 0.02 2.36 -3.71 0.03 0.26 ...
## $ gyros_arm_y    : num 0.48 0.85 -1.36 -0.51 0.79 0.05 -1.01 1.85 -0.02 -0.5 ...
## $ gyros_arm_z    : num -0.18 -0.43 1.13 0.92 -0.54 -0.07 0.89 -0.69 -0.02 0.79 ...
## $ accel_arm_x    : int 16 -290 -341 -238 -197 -26 99 -98 -287 -301 ...
## $ accel_arm_y    : int 38 215 245 -57 200 130 79 175 111 -42 ...
## $ accel_arm_z    : int 93 -90 -87 6 -30 -19 -67 -78 -122 -80 ...
## $ magnet_arm_x   : int -326 -325 -264 -173 -170 396 702 535 -367 -420 ...
## $ magnet_arm_y   : int 385 447 474 257 275 176 15 215 335 294 ...
## $ magnet_arm_z   : int 481 434 413 633 617 516 217 385 520 493 ...
## $ roll_dumbbell  : num -17.7 54.5 57.1 43.1 -101.4 ...
## $ pitch_dumbbell : num 25 -53.7 -51.4 -30 -53.4 ...
## $ yaw_dumbbell   : num 126.2 -75.5 -75.2 -103.3 -14.2 ...
## $ total_accel_dumbbell: int 9 31 29 18 4 29 29 29 3 2 ...
## $ gyros_dumbbell_x : num 0.64 0.34 0.39 0.1 0.29 -0.59 0.34 0.37 0.03 0.42 ...
## $ gyros_dumbbell_y : num 0.06 0.05 0.14 -0.02 -0.47 0.8 0.16 0.14 -0.21 0.51 ...
## $ gyros_dumbbell_z : num -0.61 -0.71 -0.34 0.05 -0.46 1.1 -0.23 -0.39 -0.21 -0.03 ...
## $ accel_dumbbell_x : int 21 -153 -141 -51 -18 -138 -145 -140 0 -7 ...
## $ accel_dumbbell_y : int -15 155 155 72 -30 166 150 159 25 -20 ...
## $ accel_dumbbell_z : int 81 -205 -196 -148 -5 -186 -190 -191 9 7 ...
## $ magnet_dumbbell_x : int 523 -502 -506 -576 -424 -543 -484 -515 -519 -531 ...
## $ magnet_dumbbell_y : int -528 388 349 238 252 262 354 350 348 321 ...
## $ magnet_dumbbell_z : int -56 -36 41 53 312 96 97 53 -32 -164 ...
## $ roll_forearm   : num 141 109 131 0 -176 150 155 -161 15.5 13.2 ...
## $ pitch_forearm  : num 49.3 -17.6 -32.6 0 -2.16 1.46 34.5 43.6 -63.5 19.4 ...
## $ yaw_forearm    : num 156 106 93 0 -47.9 89.7 152 -89.5 -139 -105 ...
## $ total_accel_forearm : int 33 39 34 43 24 43 32 47 36 24 ...
## $ gyros_forearm_x : num 0.74 1.12 0.18 1.38 -0.75 -0.88 -0.53 0.63 0.03 0.02 ...
## $ gyros_forearm_y : num -3.34 -2.78 -0.79 0.69 3.1 4.26 1.8 -0.74 0.02 0.13 ...
## $ gyros_forearm_z : num -0.59 -0.18 0.28 1.8 0.8 1.35 0.75 0.49 -0.02 -0.07 ...
## $ accel_forearm_x : int -110 212 154 -92 131 230 -192 -151 195 -212 ...
## $ accel_forearm_y : int 267 297 271 406 -93 322 170 -331 204 98 ...
## $ accel_forearm_z : int -149 -118 -129 -39 172 -144 -175 -282 -217 -7 ...
## $ magnet_forearm_x : int -714 -237 -51 -233 375 -300 -678 -109 0 -403 ...
## $ magnet_forearm_y : int 419 791 698 783 -787 800 284 -619 652 723 ...
## $ magnet_forearm_z : int 617 873 783 521 91 884 585 -32 469 512 ...
## $ problem_id     : int 1 2 3 4 5 6 7 8 9 10 ...
```

```
# Variables "X.1", "X", user_name", "raw_timestamp_part_1", "raw_timestamp_part_2" "cvtd_timestamp", "
traindataset <-traindataset[,-c(1:8)]
testdataset <-testdataset[,-c(1:8)]
#saved to working dir
write.csv(traindataset, "traindataset.csv")
write.csv(testdataset , "testdataset.csv")
# Review final datasets
head(traindataset)
```

```
## roll_belt pitch_belt yaw_belt total_accel_belt gyros_belt_x gyros_belt_y
## 1      1.41      8.07      -94.4              3          0.00          0.00
## 2      1.41      8.07      -94.4              3          0.02          0.00
## 3      1.42      8.07      -94.4              3          0.00          0.00
## 4      1.48      8.05      -94.4              3          0.02          0.00
## 5      1.48      8.07      -94.4              3          0.02          0.02
```

## 6	1.45	8.06	-94.4	3	0.02	0.00
##	gyros_belt_z	accel_belt_x	accel_belt_y	accel_belt_z	magnet_belt_x	
## 1	-0.02	-21	4	22	-3	
## 2	-0.02	-22	4	22	-7	
## 3	-0.02	-20	5	23	-2	
## 4	-0.03	-22	3	21	-6	
## 5	-0.02	-21	2	24	-6	
## 6	-0.02	-21	4	21	0	
##	magnet_belt_y	magnet_belt_z	roll_arm	pitch_arm	yaw_arm	total_accel_arm
## 1	599	-313	-128	22.5	-161	34
## 2	608	-311	-128	22.5	-161	34
## 3	600	-305	-128	22.5	-161	34
## 4	604	-310	-128	22.1	-161	34
## 5	600	-302	-128	22.1	-161	34
## 6	603	-312	-128	22.0	-161	34
##	gyros_arm_x	gyros_arm_y	gyros_arm_z	accel_arm_x	accel_arm_y	accel_arm_z
## 1	0.00	0.00	-0.02	-288	109	-123
## 2	0.02	-0.02	-0.02	-290	110	-125
## 3	0.02	-0.02	-0.02	-289	110	-126
## 4	0.02	-0.03	0.02	-289	111	-123
## 5	0.00	-0.03	0.00	-289	111	-123
## 6	0.02	-0.03	0.00	-289	111	-122
##	magnet_arm_x	magnet_arm_y	magnet_arm_z	roll_dumbbell	pitch_dumbbell	
## 1	-368	337	516	13.05217	-70.49400	
## 2	-369	337	513	13.13074	-70.63751	
## 3	-368	344	513	12.85075	-70.27812	
## 4	-372	344	512	13.43120	-70.39379	
## 5	-374	337	506	13.37872	-70.42856	
## 6	-369	342	513	13.38246	-70.81759	
##	yaw_dumbbell	total_accel_dumbbell	gyros_dumbbell_x	gyros_dumbbell_y		
## 1	-84.87394		37	0	-0.02	
## 2	-84.71065		37	0	-0.02	
## 3	-85.14078		37	0	-0.02	
## 4	-84.87363		37	0	-0.02	
## 5	-84.85306		37	0	-0.02	
## 6	-84.46500		37	0	-0.02	
##	gyros_dumbbell_z	accel_dumbbell_x	accel_dumbbell_y	accel_dumbbell_z		
## 1	0.00	-234	47	-271		
## 2	0.00	-233	47	-269		
## 3	0.00	-232	46	-270		
## 4	-0.02	-232	48	-269		
## 5	0.00	-233	48	-270		
## 6	0.00	-234	48	-269		
##	magnet_dumbbell_x	magnet_dumbbell_y	magnet_dumbbell_z	roll_forearm		
## 1	-559		293	-65	28.4	
## 2	-555		296	-64	28.3	
## 3	-561		298	-63	28.3	
## 4	-552		303	-60	28.1	
## 5	-554		292	-68	28.0	
## 6	-558		294	-66	27.9	
##	pitch_forearm	yaw_forearm	total_accel_forearm	gyros_forearm_x		
## 1	-63.9	-153		36	0.03	
## 2	-63.9	-153		36	0.02	
## 3	-63.9	-152		36	0.03	

```

## 4      -63.9      -152          36      0.02
## 5      -63.9      -152          36      0.02
## 6      -63.9      -152          36      0.02
##   gyros_forearm_y gyros_forearm_z accel_forearm_x accel_forearm_y
## 1           0.00          -0.02          192          203
## 2           0.00          -0.02          192          203
## 3          -0.02           0.00          196          204
## 4          -0.02           0.00          189          206
## 5           0.00          -0.02          189          206
## 6          -0.02          -0.03          193          203
##   accel_forearm_z magnet_forearm_x magnet_forearm_y magnet_forearm_z
## 1          -215          -17          654          476
## 2          -216          -18          661          473
## 3          -213          -18          658          469
## 4          -214          -16          658          469
## 5          -214          -17          655          473
## 6          -215           -9          660          478
##   classe
## 1      A
## 2      A
## 3      A
## 4      A
## 5      A
## 6      A

```

```
head(testdataset)
```

```

##   roll_belt pitch_belt yaw_belt total_accel_belt gyros_belt_x gyros_belt_y
## 1    123.00    27.00   -4.75           20      -0.50      -0.02
## 2     1.02     4.87  -88.90            4      -0.06      -0.02
## 3     0.87     1.82  -88.50            5       0.05       0.02
## 4    125.00   -41.60  162.00           17       0.11       0.11
## 5     1.35     3.33  -88.60            3       0.03       0.02
## 6    -5.92     1.59  -87.70            4       0.10       0.05
##   gyros_belt_z accel_belt_x accel_belt_y accel_belt_z magnet_belt_x
## 1      -0.46       -38           69      -179       -13
## 2      -0.07       -13           11        39        43
## 3       0.03         1           -1       49        29
## 4      -0.16        46           45     -156       169
## 5       0.00        -8            4        27        33
## 6      -0.13       -11          -16        38        31
##   magnet_belt_y magnet_belt_z roll_arm pitch_arm yaw_arm total_accel_arm
## 1         581       -382     40.7   -27.80    178         10
## 2         636       -309      0.0     0.00      0         38
## 3         631       -312      0.0     0.00      0         44
## 4         608       -304   -109.0    55.00   -142         25
## 5         566       -418    76.1     2.76    102         29
## 6         638       -291      0.0     0.00      0         14
##   gyros_arm_x gyros_arm_y gyros_arm_z accel_arm_x accel_arm_y accel_arm_z
## 1      -1.65      0.48     -0.18         16         38         93
## 2      -1.17      0.85     -0.43       -290        215        -90
## 3       2.10     -1.36      1.13       -341        245        -87
## 4       0.22     -0.51      0.92       -238        -57          6
## 5      -1.96      0.79     -0.54       -197        200       -30
## 6       0.02      0.05     -0.07        -26        130       -19

```

```

## magnet_arm_x magnet_arm_y magnet_arm_z roll_dumbbell pitch_dumbbell
## 1 -326 385 481 -17.73748 24.96085
## 2 -325 447 434 54.47761 -53.69758
## 3 -264 474 413 57.07031 -51.37303
## 4 -173 257 633 43.10927 -30.04885
## 5 -170 275 617 -101.38396 -53.43952
## 6 396 176 516 62.18750 -50.55595
## yaw_dumbbell total_accel_dumbbell gyros_dumbbell_x gyros_dumbbell_y
## 1 126.23596 9 0.64 0.06
## 2 -75.51480 31 0.34 0.05
## 3 -75.20287 29 0.39 0.14
## 4 -103.32003 18 0.10 -0.02
## 5 -14.19542 4 0.29 -0.47
## 6 -71.12063 29 -0.59 0.80
## gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y accel_dumbbell_z
## 1 -0.61 21 -15 81
## 2 -0.71 -153 155 -205
## 3 -0.34 -141 155 -196
## 4 0.05 -51 72 -148
## 5 -0.46 -18 -30 -5
## 6 1.10 -138 166 -186
## magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z roll_forearm
## 1 523 -528 -56 141
## 2 -502 388 -36 109
## 3 -506 349 41 131
## 4 -576 238 53 0
## 5 -424 252 312 -176
## 6 -543 262 96 150
## pitch_forearm yaw_forearm total_accel_forearm gyros_forearm_x
## 1 49.30 156.0 33 0.74
## 2 -17.60 106.0 39 1.12
## 3 -32.60 93.0 34 0.18
## 4 0.00 0.0 43 1.38
## 5 -2.16 -47.9 24 -0.75
## 6 1.46 89.7 43 -0.88
## gyros_forearm_y gyros_forearm_z accel_forearm_x accel_forearm_y
## 1 -3.34 -0.59 -110 267
## 2 -2.78 -0.18 212 297
## 3 -0.79 0.28 154 271
## 4 0.69 1.80 -92 406
## 5 3.10 0.80 131 -93
## 6 4.26 1.35 230 322
## accel_forearm_z magnet_forearm_x magnet_forearm_y magnet_forearm_z
## 1 -149 -714 419 617
## 2 -118 -237 791 873
## 3 -129 -51 698 783
## 4 -39 -233 783 521
## 5 172 375 -787 91
## 6 -144 -300 800 884
## problem_id
## 1 1
## 2 2
## 3 3
## 4 4

```

```
## 5          5
## 6          6
dim(traindataset)

## [1] 19622    53
dim(testdataset)

## [1] 20 53
```

3. Partitioning the training data set to allow cross-validation

traindataset: 53 variables and 19622 obs

testdataset: 53 variables and 20 obs.

```
#In order to perform cross-validation, the training data set is partitioned into 2 sets: subTraining (75%)
subsamples <- createDataPartition(y=traindataset$classe, p=0.75, list=FALSE)
subTraining <- traindataset[subsamples, ]
subTesting <- traindataset[-subsamples, ]
dim(subTraining)

## [1] 14718    53
dim(subTesting)

## [1] 4904    53
head(subTraining)

##   roll_belt pitch_belt yaw_belt total_accel_belt gyros_belt_x gyros_belt_y
## 2      1.41      8.07   -94.4              3         0.02         0.00
## 3      1.42      8.07   -94.4              3         0.00         0.00
## 4      1.48      8.05   -94.4              3         0.02         0.00
## 5      1.48      8.07   -94.4              3         0.02         0.02
## 6      1.45      8.06   -94.4              3         0.02         0.00
## 7      1.42      8.09   -94.4              3         0.02         0.00
##   gyros_belt_z accel_belt_x accel_belt_y accel_belt_z magnet_belt_x
## 2      -0.02      -22          4          22          -7
## 3      -0.02      -20          5          23          -2
## 4      -0.03      -22          3          21          -6
## 5      -0.02      -21          2          24          -6
## 6      -0.02      -21          4          21           0
## 7      -0.02      -22          3          21          -4
##   magnet_belt_y magnet_belt_z roll_arm pitch_arm yaw_arm total_accel_arm
## 2          608      -311      -128      22.5     -161          34
## 3          600      -305      -128      22.5     -161          34
## 4          604      -310      -128      22.1     -161          34
## 5          600      -302      -128      22.1     -161          34
## 6          603      -312      -128      22.0     -161          34
## 7          599      -311      -128      21.9     -161          34
##   gyros_arm_x gyros_arm_y gyros_arm_z accel_arm_x accel_arm_y accel_arm_z
## 2         0.02      -0.02      -0.02      -290        110       -125
```

## 3	0.02	-0.02	-0.02	-289	110	-126
## 4	0.02	-0.03	0.02	-289	111	-123
## 5	0.00	-0.03	0.00	-289	111	-123
## 6	0.02	-0.03	0.00	-289	111	-122
## 7	0.00	-0.03	0.00	-289	111	-125
##	magnet_arm_x	magnet_arm_y	magnet_arm_z	roll_dumbbell	pitch_dumbbell	
## 2	-369	337	513	13.13074	-70.63751	
## 3	-368	344	513	12.85075	-70.27812	
## 4	-372	344	512	13.43120	-70.39379	
## 5	-374	337	506	13.37872	-70.42856	
## 6	-369	342	513	13.38246	-70.81759	
## 7	-373	336	509	13.12695	-70.24757	
##	yaw_dumbbell	total_accel_dumbbell	gyros_dumbbell_x	gyros_dumbbell_y		
## 2	-84.71065		37	0	-0.02	
## 3	-85.14078		37	0	-0.02	
## 4	-84.87363		37	0	-0.02	
## 5	-84.85306		37	0	-0.02	
## 6	-84.46500		37	0	-0.02	
## 7	-85.09961		37	0	-0.02	
##	gyros_dumbbell_z	accel_dumbbell_x	accel_dumbbell_y	accel_dumbbell_z		
## 2	0.00	-233	47	-269		
## 3	0.00	-232	46	-270		
## 4	-0.02	-232	48	-269		
## 5	0.00	-233	48	-270		
## 6	0.00	-234	48	-269		
## 7	0.00	-232	47	-270		
##	magnet_dumbbell_x	magnet_dumbbell_y	magnet_dumbbell_z	roll_forearm		
## 2	-555	296	-64	28.3		
## 3	-561	298	-63	28.3		
## 4	-552	303	-60	28.1		
## 5	-554	292	-68	28.0		
## 6	-558	294	-66	27.9		
## 7	-551	295	-70	27.9		
##	pitch_forearm	yaw_forearm	total_accel_forearm	gyros_forearm_x		
## 2	-63.9	-153		36	0.02	
## 3	-63.9	-152		36	0.03	
## 4	-63.9	-152		36	0.02	
## 5	-63.9	-152		36	0.02	
## 6	-63.9	-152		36	0.02	
## 7	-63.9	-152		36	0.02	
##	gyros_forearm_y	gyros_forearm_z	accel_forearm_x	accel_forearm_y		
## 2	0.00	-0.02	192	203		
## 3	-0.02	0.00	196	204		
## 4	-0.02	0.00	189	206		
## 5	0.00	-0.02	189	206		
## 6	-0.02	-0.03	193	203		
## 7	0.00	-0.02	195	205		
##	accel_forearm_z	magnet_forearm_x	magnet_forearm_y	magnet_forearm_z		
## 2	-216	-18	661	473		
## 3	-213	-18	658	469		
## 4	-214	-16	658	469		
## 5	-214	-17	655	473		
## 6	-215	-9	660	478		
## 7	-215	-18	659	470		

```
## classe
## 2      A
## 3      A
## 4      A
## 5      A
## 6      A
## 7      A
```

```
head(subTesting)
```

```
## roll_belt pitch_belt yaw_belt total_accel_belt gyros_belt_x
## 1      1.41      8.07     -94.4              3      0.00
## 21     1.60      8.10     -94.4              3      0.02
## 22     1.57      8.09     -94.4              3      0.02
## 23     1.56      8.10     -94.3              3      0.02
## 25     1.53      8.11     -94.4              3      0.03
## 26     1.55      8.09     -94.4              3      0.02
## gyros_belt_y gyros_belt_z accel_belt_x accel_belt_y accel_belt_z
## 1      0.00      -0.02      -21              4      22
## 21     0.00      -0.02      -20              1      20
## 22     0.02      -0.02      -21              3      21
## 23     0.00      -0.02      -21              4      21
## 25     0.00      0.00      -19              4      21
## 26     0.00      0.00      -21              3      22
## magnet_belt_x magnet_belt_y magnet_belt_z roll_arm pitch_arm yaw_arm
## 1      -3      599      -313      -128      22.5     -161
## 21     -10     607      -304      -129      20.9     -161
## 22      -2     604      -313      -129      20.8     -161
## 23      -4     606      -311      -129      20.7     -161
## 25      -8     605      -319      -129      20.7     -161
## 26     -10     601      -312      -129      20.7     -161
## total_accel_arm gyros_arm_x gyros_arm_y gyros_arm_z accel_arm_x
## 1      34      0.00      0.00      -0.02      -288
## 21     34      0.03      -0.02      -0.02      -288
## 22     34      0.03      -0.02      -0.02      -289
## 23     34      0.02      -0.02      -0.02      -290
## 25     34     -0.02      -0.02      0.00      -289
## 26     34     -0.02      -0.02      -0.02      -290
## accel_arm_y accel_arm_z magnet_arm_x magnet_arm_y magnet_arm_z
## 1      109     -123     -368      337      516
## 21     111     -124     -375      337      513
## 22     111     -123     -372      338      510
## 23     110     -123     -373      333      509
## 25     109     -123     -370      340      512
## 26     108     -123     -366      346      511
## roll_dumbbell pitch_dumbbell yaw_dumbbell total_accel_dumbbell
## 1      13.05217     -70.49400     -84.87394      37
## 21     13.38246     -70.81759     -84.46500      37
## 22     13.37872     -70.42856     -84.85306      37
## 23     13.35451     -70.63995     -84.64919      37
## 25     13.05217     -70.49400     -84.87394      37
## 26     12.80060     -70.31305     -85.11886      37
## gyros_dumbbell_x gyros_dumbbell_y gyros_dumbbell_z accel_dumbbell_x
## 1      0      -0.02      0.00      -234
## 21     0      -0.02      0.00      -234
```

```

## 22          0          -0.02          0.00          -233
## 23          0          -0.02          0.00          -234
## 25          0          -0.02          0.00          -234
## 26          0          -0.02         -0.02          -233
##   accel_dumbbell_y accel_dumbbell_z magnet_dumbbell_x magnet_dumbbell_y
## 1             47          -271          -559          293
## 21            48          -269          -554          299
## 22            48          -270          -554          301
## 23            48          -270          -557          294
## 25            47          -271          -555          290
## 26            46          -271          -563          294
##   magnet_dumbbell_z roll_forearm pitch_forearm yaw_forearm
## 1             -65          28.4          -63.9          -153
## 21            -72          26.9          -63.9          -151
## 22            -65          27.0          -63.9          -151
## 23            -69          26.9          -63.8          -151
## 25            -68          27.1          -63.7          -151
## 26            -72          27.0          -63.7          -151
##   total_accel_forearm gyros_forearm_x gyros_forearm_y gyros_forearm_z
## 1             36          0.03          0.00         -0.02
## 21            36          0.03         -0.03         -0.02
## 22            36          0.02         -0.03         -0.02
## 23            36          0.02         -0.02         -0.02
## 25            36          0.05         -0.03          0.00
## 26            36          0.03          0.00          0.00
##   accel_forearm_x accel_forearm_y accel_forearm_z magnet_forearm_x
## 1             192          203          -215          -17
## 21            194          208          -214          -11
## 22            191          206          -213          -17
## 23            194          206          -214          -10
## 25            191          202          -214          -14
## 26            190          203          -216          -16
##   magnet_forearm_y magnet_forearm_z classe
## 1             654          476          A
## 21            654          469          A
## 22            654          478          A
## 23            653          467          A
## 25            667          470          A
## 26            658          462          A

```

4a. First Prediction model with Decision Tree

```

# Using rpart: Decision Tree
decisiontreemodel <- rpart(classe ~ ., data=subTraining, method="class")
decisiontreemodel_summary = summary(decisiontreemodel)

## Call:
## rpart(formula = classe ~ ., data = subTraining, method = "class")
##   n= 14718
##
##           CP nsplit rel error   xerror   xstd
## 1  0.11535175      0 1.0000000 1.0000000 0.005195739

```

```

## 2 0.05987531      1 0.8846482 0.8858825 0.005548315
## 3 0.03446312      4 0.7050223 0.7814488 0.005718364
## 4 0.02990601      5 0.6705592 0.6623944 0.005751173
## 5 0.02212095      6 0.6406532 0.6061901 0.005708272
## 6 0.02050698     11 0.5155226 0.5525491 0.005631592
## 7 0.01955758     12 0.4950157 0.4999525 0.005521102
## 8 0.01898794     13 0.4754581 0.4693819 0.005440000
## 9 0.01433590     15 0.4374822 0.4437482 0.005361931
## 10 0.01101301     16 0.4231463 0.4240008 0.005295259
## 11 0.01063325     17 0.4121333 0.3895376 0.005164571
## 12 0.01044337     21 0.3625748 0.3789044 0.005120396
## 13 0.01000000     22 0.3521314 0.3724485 0.005092652
##
## Variable importance
##          roll_belt          accel_belt_z          pitch_belt
##              12              7              6
##          pitch_forearm          roll_forearm          magnet_dumbbell_y
##              6              5              4
##          accel_dumbbell_y total_accel_dumbbell          total_accel_belt
##              4              4              4
##              yaw_belt          magnet_belt_z          accel_forearm_x
##              4              4              3
##          accel_belt_y          magnet_belt_x          roll_dumbbell
##              3              3              3
##          magnet_dumbbell_z          accel_belt_x          accel_dumbbell_x
##              3              3              2
##          magnet_forearm_z          magnet_forearm_y          accel_dumbbell_z
##              2              2              2
##          magnet_forearm_x          yaw_forearm          magnet_belt_y
##              2              2              1
##          accel_forearm_y          accel_forearm_z          gyros_belt_z
##              1              1              1
##          yaw_dumbbell          yaw_arm          magnet_arm_y
##              1              1              1
##          accel_arm_x          pitch_arm
##              1              1
##
## Node number 1: 14718 observations,      complexity param=0.1153518
## predicted class=A expected loss=0.7156543 P(node) =1
## class counts: 4185 2848 2567 2412 2706
## probabilities: 0.284 0.194 0.174 0.164 0.184
## left son=2 (13483 obs) right son=3 (1235 obs)
## Primary splits:
##          roll_belt          < 130.5          to the left, improve=1110.8160, (0 missing)
##          pitch_forearm          < -34.35          to the left, improve= 801.1791, (0 missing)
##          accel_belt_z          < -187.5          to the right, improve= 679.0521, (0 missing)
##          magnet_belt_y          < 555.5          to the right, improve= 638.1469, (0 missing)
##          total_accel_belt          < 20.5          to the left, improve= 567.5270, (0 missing)
## Surrogate splits:
##          accel_belt_z          < -187.5          to the right, agree=0.967, adj=0.602, (0 split)
##          total_accel_belt          < 20.5          to the left, agree=0.960, adj=0.518, (0 split)
##          magnet_belt_z          < -451.5          to the right, agree=0.935, adj=0.219, (0 split)
##          magnet_belt_y          < 552.5          to the right, agree=0.934, adj=0.215, (0 split)
##          accel_belt_x          < 55.5          to the left, agree=0.923, adj=0.082, (0 split)

```

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##
## Node number 2: 13483 observations,      complexity param=0.05987531
## predicted class=A expected loss=0.6903508 P(node) =0.9160891
## class counts: 4175 2848 2567 2412 1481
## probabilities: 0.310 0.211 0.190 0.179 0.110
## left son=4 (1163 obs) right son=5 (12320 obs)
## Primary splits:
## pitch_forearm < -34.35 to the left, improve=757.7394, (0 missing)
## roll_forearm < 123.5 to the left, improve=455.0585, (0 missing)
## magnet_dumbbell_y < 439.5 to the left, improve=427.6583, (0 missing)
## magnet_arm_x < 70.5 to the left, improve=425.3833, (0 missing)
## accel_arm_x < -270.5 to the left, improve=413.8988, (0 missing)
## Surrogate splits:
## accel_forearm_x < 220.5 to the right, agree=0.934, adj=0.238, (0 split)
## accel_dumbbell_x < -199.5 to the left, agree=0.932, adj=0.208, (0 split)
## total_accel_dumbbell < 36.5 to the right, agree=0.931, adj=0.206, (0 split)
## yaw_arm < -160.5 to the left, agree=0.926, adj=0.137, (0 split)
## accel_dumbbell_z < -220.5 to the left, agree=0.925, adj=0.136, (0 split)
##
## Node number 3: 1235 observations
## predicted class=E expected loss=0.008097166 P(node) =0.08391086
## class counts: 10 0 0 0 1225
## probabilities: 0.008 0.000 0.000 0.000 0.992
##
## Node number 4: 1163 observations
## predicted class=A expected loss=0.003439381 P(node) =0.07901889
## class counts: 1159 4 0 0 0
## probabilities: 0.997 0.003 0.000 0.000 0.000
##
## Node number 5: 12320 observations,      complexity param=0.05987531
## predicted class=A expected loss=0.7551948 P(node) =0.8370703
## class counts: 3016 2844 2567 2412 1481
## probabilities: 0.245 0.231 0.208 0.196 0.120
## left son=10 (10462 obs) right son=11 (1858 obs)
## Primary splits:
## magnet_dumbbell_y < 439.5 to the left, improve=346.2935, (0 missing)
## yaw_belt < 169.5 to the right, improve=344.3402, (0 missing)
## roll_forearm < 126.5 to the left, improve=332.6486, (0 missing)
## roll_dumbbell < 63.49251 to the left, improve=297.3350, (0 missing)
## magnet_dumbbell_x < -446.5 to the left, improve=275.8782, (0 missing)
## Surrogate splits:
## roll_dumbbell < 81.7374 to the left, agree=0.900, adj=0.339, (0 split)
## accel_dumbbell_y < 195.5 to the left, agree=0.876, adj=0.179, (0 split)
## total_accel_dumbbell < 31.5 to the left, agree=0.857, adj=0.054, (0 split)
## gyros_dumbbell_y < 1.21 to the left, agree=0.856, adj=0.046, (0 split)
## accel_forearm_x < -401.5 to the right, agree=0.855, adj=0.036, (0 split)
##
## Node number 10: 10462 observations,      complexity param=0.05987531
## predicted class=A expected loss=0.7167846 P(node) =0.7108303
## class counts: 2963 1898 2490 1985 1126
## probabilities: 0.283 0.181 0.238 0.190 0.108
## left son=20 (6480 obs) right son=21 (3982 obs)
## Primary splits:
## roll_forearm < 123.5 to the left, improve=366.3309, (0 missing)

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##      yaw_belt          < 169.5      to the right, improve=317.5318, (0 missing)
##      magnet_dumbbell_z < -17.5     to the left,  improve=283.0673, (0 missing)
##      accel_dumbbell_y  < -40.5     to the right, improve=247.3432, (0 missing)
##      roll_arm          < -60.75    to the left,  improve=233.7621, (0 missing)
##  Surrogate splits:
##      total_accel_dumbbell < 22.5     to the left,  agree=0.726, adj=0.280, (0 split)
##      accel_dumbbell_x    < -65.5     to the right, agree=0.724, adj=0.274, (0 split)
##      roll_belt          < 1.315     to the right, agree=0.723, adj=0.272, (0 split)
##      accel_belt_z        < -3.5     to the left,  agree=0.722, adj=0.268, (0 split)
##      yaw_forearm        < 64.9     to the left,  agree=0.721, adj=0.267, (0 split)
##
## Node number 11: 1858 observations,      complexity param=0.02990601
## predicted class=B expected loss=0.4908504 P(node) =0.12624
## class counts:      53   946   77   427   355
## probabilities: 0.029 0.509 0.041 0.230 0.191
## left son=22 (1315 obs) right son=23 (543 obs)
## Primary splits:
##      total_accel_dumbbell < 5.5      to the right, improve=298.3218, (0 missing)
##      accel_dumbbell_y    < 46.5     to the right, improve=254.0723, (0 missing)
##      yaw_belt            < -2.825   to the left,  improve=229.3211, (0 missing)
##      roll_belt           < -0.58    to the right, improve=224.4949, (0 missing)
##      magnet_belt_z       < -326.5   to the right, improve=207.8074, (0 missing)
##  Surrogate splits:
##      accel_dumbbell_y    < 45.5     to the right, agree=0.968, adj=0.891, (0 split)
##      yaw_belt            < -3.37    to the left,  agree=0.842, adj=0.459, (0 split)
##      accel_forearm_x     < -293.5   to the right, agree=0.827, adj=0.407, (0 split)
##      roll_belt           < 117.5    to the left,  agree=0.818, adj=0.376, (0 split)
##      accel_belt_y        < 48.5     to the left,  agree=0.816, adj=0.372, (0 split)
##
## Node number 20: 6480 observations,      complexity param=0.02212095
## predicted class=A expected loss=0.5921296 P(node) =0.4402772
## class counts: 2643 1183 1171 1093 390
## probabilities: 0.408 0.183 0.181 0.169 0.060
## left son=40 (2237 obs) right son=41 (4243 obs)
## Primary splits:
##      magnet_dumbbell_z < -25.5     to the left,  improve=349.5423, (0 missing)
##      roll_forearm      < -131.5    to the right, improve=298.4516, (0 missing)
##      accel_dumbbell_y  < -40.5     to the right, improve=289.6267, (0 missing)
##      pitch_belt        < 15.35     to the right, improve=231.0545, (0 missing)
##      yaw_belt          < 169.5     to the right, improve=211.3985, (0 missing)
##  Surrogate splits:
##      pitch_belt        < 15.25     to the right, agree=0.882, adj=0.657, (0 split)
##      accel_belt_x       < -19.5     to the left,  agree=0.842, adj=0.543, (0 split)
##      magnet_belt_x      < 25.5     to the left,  agree=0.826, adj=0.495, (0 split)
##      accel_belt_y       < 55.5     to the right, agree=0.821, adj=0.481, (0 split)
##      roll_forearm       < 0.005    to the right, agree=0.772, adj=0.339, (0 split)
##
## Node number 21: 3982 observations,      complexity param=0.03446312
## predicted class=C expected loss=0.6687594 P(node) =0.2705531
## class counts:      320   715  1319   892   736
## probabilities: 0.080 0.180 0.331 0.224 0.185
## left son=42 (2330 obs) right son=43 (1652 obs)
## Primary splits:
##      magnet_dumbbell_y < 291.5     to the left,  improve=192.7161, (0 missing)

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##      accel_forearm_x    < -107.5    to the right, improve=183.4029, (0 missing)
##      magnet_arm_y      < 272.5     to the right, improve=168.3041, (0 missing)
##      magnet_forearm_z  < -251      to the left,  improve=163.5566, (0 missing)
##      magnet_dumbbell_z < 286.5     to the right, improve=160.0265, (0 missing)
##      Surrogate splits:
##      roll_dumbbell      < 20.87401  to the left,  agree=0.828, adj=0.585, (0 split)
##      accel_dumbbell_y   < 17.5      to the left,  agree=0.822, adj=0.570, (0 split)
##      total_accel_dumbbell < 15.5    to the left,  agree=0.754, adj=0.406, (0 split)
##      accel_dumbbell_z   < -104      to the right, agree=0.711, adj=0.303, (0 split)
##      accel_dumbbell_x   < -87.5     to the right, agree=0.709, adj=0.300, (0 split)
##
## Node number 22: 1315 observations,      complexity param=0.01955758
##      predicted class=B expected loss=0.3437262 P(node) =0.08934638
##      class counts:      53   863   75   29   295
##      probabilities: 0.040 0.656 0.057 0.022 0.224
##      left son=44 (1109 obs) right son=45 (206 obs)
##      Primary splits:
##      roll_belt          < -0.58      to the right, improve=253.47770, (0 missing)
##      gyros_belt_z        < -0.255     to the right, improve=133.11020, (0 missing)
##      magnet_belt_z       < -287.5     to the left,  improve=108.67430, (0 missing)
##      accel_belt_y        < -1.5       to the right, improve= 98.78198, (0 missing)
##      magnet_dumbbell_z  < 17.5        to the left,  improve= 98.25329, (0 missing)
##      Surrogate splits:
##      magnet_belt_z < -286.5    to the left,  agree=0.911, adj=0.432, (0 split)
##      accel_belt_y  < -1.5      to the right, agree=0.900, adj=0.359, (0 split)
##      gyros_belt_y  < -0.04     to the right, agree=0.873, adj=0.189, (0 split)
##      magnet_belt_x < -7.5      to the right, agree=0.870, adj=0.170, (0 split)
##      gyros_belt_z  < -0.27     to the right, agree=0.868, adj=0.160, (0 split)
##
## Node number 23: 543 observations
##      predicted class=D expected loss=0.267035 P(node) =0.0368936
##      class counts:      0    83    2   398    60
##      probabilities: 0.000 0.153 0.004 0.733 0.110
##
## Node number 40: 2237 observations,      complexity param=0.01101301
##      predicted class=A expected loss=0.3330353 P(node) =0.1519908
##      class counts: 1492  453   42  181   69
##      probabilities: 0.667 0.203 0.019 0.081 0.031
##      left son=80 (1859 obs) right son=81 (378 obs)
##      Primary splits:
##      roll_forearm       < -136.5     to the right, improve=207.2354, (0 missing)
##      accel_dumbbell_y   < -50.5       to the right, improve=145.0686, (0 missing)
##      magnet_forearm_z   < 181.5       to the right, improve=125.2758, (0 missing)
##      magnet_forearm_y   < -258.5     to the right, improve=118.6775, (0 missing)
##      gyros_arm_x        < -3.165     to the right, improve=116.4885, (0 missing)
##      Surrogate splits:
##      magnet_forearm_y   < -371.5     to the right, agree=0.911, adj=0.471, (0 split)
##      magnet_forearm_z   < 181.5       to the right, agree=0.903, adj=0.426, (0 split)
##      accel_forearm_z    < -203.5     to the right, agree=0.893, adj=0.365, (0 split)
##      gyros_arm_x        < -3.19      to the right, agree=0.877, adj=0.272, (0 split)
##      gyros_arm_y        < 1.34       to the left,  agree=0.868, adj=0.217, (0 split)
##
## Node number 41: 4243 observations,      complexity param=0.02212095
##      predicted class=A expected loss=0.7287297 P(node) =0.2882865

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##      class counts: 1151   730  1129   912   321
##      probabilities: 0.271 0.172 0.266 0.215 0.076
##      left son=82 (577 obs) right son=83 (3666 obs)
##      Primary splits:
##          yaw_belt          < 168.5      to the right, improve=291.4081, (0 missing)
##          accel_dumbbell_y  < -40.5      to the right, improve=273.5031, (0 missing)
##          pitch_belt        < -42.45     to the left,  improve=228.4282, (0 missing)
##          roll_dumbbell     < -88.98732  to the right, improve=199.9125, (0 missing)
##          yaw_arm           < -115       to the left,  improve=180.6568, (0 missing)
##      Surrogate splits:
##          pitch_belt        < -43.55     to the left,  agree=0.910, adj=0.336, (0 split)
##          pitch_arm         < 68.15      to the right, agree=0.881, adj=0.125, (0 split)
##          magnet_belt_x     < 193.5      to the right, agree=0.870, adj=0.043, (0 split)
##          magnet_arm_y      < 491        to the right, agree=0.869, adj=0.038, (0 split)
##          gyros_forearm_x   < 1.95       to the right, agree=0.866, adj=0.016, (0 split)
##
##      Node number 42: 2330 observations,      complexity param=0.0143359
##      predicted class=C expected loss=0.5145923 P(node) =0.1583096
##      class counts:   224   306  1131   341   328
##      probabilities: 0.096 0.131 0.485 0.146 0.141
##      left son=84 (187 obs) right son=85 (2143 obs)
##      Primary splits:
##          magnet_forearm_z  < -251        to the left,  improve=154.6147, (0 missing)
##          magnet_dumbbell_z < 286.5     to the right, improve=150.3559, (0 missing)
##          magnet_forearm_y  < 841          to the right, improve=134.6032, (0 missing)
##          accel_forearm_z   < -168.5      to the right, improve=116.7137, (0 missing)
##          gyros_dumbbell_y  < -0.25       to the left,  improve=102.8975, (0 missing)
##      Surrogate splits:
##          magnet_forearm_y  < 815.5       to the right, agree=0.983, adj=0.786, (0 split)
##          accel_forearm_z   < 195.5       to the right, agree=0.930, adj=0.123, (0 split)
##          magnet_forearm_x  < -720.5      to the left,  agree=0.927, adj=0.086, (0 split)
##          pitch_forearm     < -22.7       to the left,  agree=0.926, adj=0.080, (0 split)
##          gyros_dumbbell_x  < -1.095     to the left,  agree=0.925, adj=0.070, (0 split)
##
##      Node number 43: 1652 observations,      complexity param=0.02050698
##      predicted class=D expected loss=0.6664649 P(node) =0.1122435
##      class counts:    96   409   188   551   408
##      probabilities: 0.058 0.248 0.114 0.334 0.247
##      left son=86 (1070 obs) right son=87 (582 obs)
##      Primary splits:
##          accel_forearm_x   < -101.5      to the right, improve=162.8788, (0 missing)
##          pitch_forearm     < 23.85       to the left,  improve=136.9468, (0 missing)
##          magnet_dumbbell_x < -84.5     to the right, improve=115.0028, (0 missing)
##          magnet_forearm_x  < -516        to the right, improve=110.6594, (0 missing)
##          accel_dumbbell_x  < 96          to the right, improve=109.4126, (0 missing)
##      Surrogate splits:
##          pitch_forearm     < 23.35       to the left,  agree=0.873, adj=0.641, (0 split)
##          magnet_forearm_x  < -514.5      to the right, agree=0.835, adj=0.531, (0 split)
##          yaw_forearm       < 118.5       to the left,  agree=0.781, adj=0.380, (0 split)
##          magnet_dumbbell_z < -9.5       to the right, agree=0.683, adj=0.100, (0 split)
##          accel_forearm_z   < -173.5     to the right, agree=0.676, adj=0.081, (0 split)
##
##      Node number 44: 1109 observations
##      predicted class=B expected loss=0.2218215 P(node) =0.07534991

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##      class counts:    53   863   75   29   89
##      probabilities: 0.048 0.778 0.068 0.026 0.080
##
## Node number 45: 206 observations
##      predicted class=E expected loss=0 P(node) =0.01399647
##      class counts:    0    0    0    0   206
##      probabilities: 0.000 0.000 0.000 0.000 1.000
##
## Node number 80: 1859 observations
##      predicted class=A expected loss=0.2157074 P(node) =0.1263079
##      class counts: 1458  303   38   52    8
##      probabilities: 0.784 0.163 0.020 0.028 0.004
##
## Node number 81: 378 observations
##      predicted class=B expected loss=0.6031746 P(node) =0.02568284
##      class counts:   34  150    4  129   61
##      probabilities: 0.090 0.397 0.011 0.341 0.161
##
## Node number 82: 577 observations
##      predicted class=A expected loss=0.1542461 P(node) =0.0392037
##      class counts:  488   50    0   36    3
##      probabilities: 0.846 0.087 0.000 0.062 0.005
##
## Node number 83: 3666 observations,      complexity param=0.02212095
##      predicted class=C expected loss=0.6920349 P(node) =0.2490828
##      class counts:   663   680  1129   876   318
##      probabilities: 0.181 0.185 0.308 0.239 0.087
##      left son=166 (3160 obs) right son=167 (506 obs)
##      Primary splits:
##      accel_dumbbell_y < -40.5      to the right, improve=236.0154, (0 missing)
##      pitch_belt      < -43.15     to the left,  improve=222.9071, (0 missing)
##      yaw_arm          < -119.5     to the left,  improve=176.4524, (0 missing)
##      magnet_forearm_x < 277.5      to the right, improve=164.9657, (0 missing)
##      roll_dumbbell    < -88.98732 to the left,  improve=161.5066, (0 missing)
##      Surrogate splits:
##      roll_dumbbell    < -90.25149 to the right, agree=0.948, adj=0.621, (0 split)
##      accel_belt_y     < 53.5       to the left,  agree=0.940, adj=0.567, (0 split)
##      pitch_belt       < 11.13      to the left,  agree=0.930, adj=0.494, (0 split)
##      magnet_dumbbell_y < 401.5     to the left,  agree=0.919, adj=0.411, (0 split)
##      pitch_dumbbell   < -38.15474 to the right, agree=0.883, adj=0.150, (0 split)
##
## Node number 84: 187 observations
##      predicted class=A expected loss=0.1925134 P(node) =0.01270553
##      class counts:   151   15    0    7   14
##      probabilities: 0.807 0.080 0.000 0.037 0.075
##
## Node number 85: 2143 observations
##      predicted class=C expected loss=0.4722352 P(node) =0.145604
##      class counts:    73   291  1131   334   314
##      probabilities: 0.034 0.136 0.528 0.156 0.147
##
## Node number 86: 1070 observations,      complexity param=0.01898794
##      predicted class=E expected loss=0.6616822 P(node) =0.0727001
##      class counts:    56   335   171   146   362

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##      probabilities: 0.052 0.313 0.160 0.136 0.338
##      left son=172 (456 obs) right son=173 (614 obs)
##      Primary splits:
##          magnet_arm_y      < 188.5      to the right, improve=92.42856, (0 missing)
##          accel_arm_x       < -97.5      to the left,  improve=79.86755, (0 missing)
##          accel_arm_y       < 150.5      to the right, improve=77.97171, (0 missing)
##          accel_dumbbell_x  < 109        to the right, improve=73.65961, (0 missing)
##          magnet_dumbbell_x < 39.5      to the right, improve=72.85758, (0 missing)
##      Surrogate splits:
##          accel_arm_x < -107.5 to the left,  agree=0.965, adj=0.919, (0 split)
##          magnet_arm_x < 268.5 to the left,  agree=0.938, adj=0.855, (0 split)
##          accel_arm_y < 153.5 to the right, agree=0.889, adj=0.739, (0 split)
##          magnet_arm_z < 352.5 to the right, agree=0.831, adj=0.603, (0 split)
##          pitch_arm    < -9.89  to the right, agree=0.757, adj=0.430, (0 split)
##
## Node number 87: 582 observations
##      predicted class=D expected loss=0.3041237 P(node) =0.03954342
##      class counts:      40      74      17      405      46
##      probabilities: 0.069 0.127 0.029 0.696 0.079
##
## Node number 166: 3160 observations,      complexity param=0.02212095
##      predicted class=D expected loss=0.7287975 P(node) =0.2147031
##      class counts:      658      656      691      857      298
##      probabilities: 0.208 0.208 0.219 0.271 0.094
##      left son=332 (382 obs) right son=333 (2778 obs)
##      Primary splits:
##          pitch_belt      < -42.85      to the left,  improve=212.5951, (0 missing)
##          yaw_arm         < -119.5      to the left,  improve=164.0981, (0 missing)
##          roll_belt       < 125.5      to the right, improve=156.0609, (0 missing)
##          magnet_forearm_x < 277.5      to the right, improve=148.9868, (0 missing)
##          accel_forearm_x < 59.5        to the right, improve=139.7594, (0 missing)
##      Surrogate splits:
##          yaw_belt        < 166.5      to the right, agree=0.897, adj=0.147, (0 split)
##          accel_arm_z     < 91.5        to the right, agree=0.885, adj=0.052, (0 split)
##          pitch_arm       < -79.8      to the left,  agree=0.884, adj=0.039, (0 split)
##          gyros_dumbbell_y < 1.07      to the right, agree=0.881, adj=0.013, (0 split)
##          accel_belt_x    < 64.5        to the right, agree=0.880, adj=0.008, (0 split)
##
## Node number 167: 506 observations
##      predicted class=C expected loss=0.1343874 P(node) =0.03437967
##      class counts:      5      24      438      19      20
##      probabilities: 0.010 0.047 0.866 0.038 0.040
##
## Node number 172: 456 observations
##      predicted class=B expected loss=0.4561404 P(node) =0.03098247
##      class counts:      8      248      108      44      48
##      probabilities: 0.018 0.544 0.237 0.096 0.105
##
## Node number 173: 614 observations
##      predicted class=E expected loss=0.4885993 P(node) =0.04171762
##      class counts:      48      87      63      102      314
##      probabilities: 0.078 0.142 0.103 0.166 0.511
##
## Node number 332: 382 observations

```

```

## predicted class=B expected loss=0.1780105 P(node) =0.02595461
## class counts: 10 314 39 10 9
## probabilities: 0.026 0.822 0.102 0.026 0.024
##
## Node number 333: 2778 observations, complexity param=0.02212095
## predicted class=D expected loss=0.6951044 P(node) =0.1887485
## class counts: 648 342 652 847 289
## probabilities: 0.233 0.123 0.235 0.305 0.104
## left son=666 (652 obs) right son=667 (2126 obs)
## Primary splits:
## roll_belt < 125.5 to the right, improve=218.5179, (0 missing)
## yaw_arm < -117.5 to the left, improve=152.4924, (0 missing)
## accel_dumbbell_z < 21.5 to the left, improve=148.8859, (0 missing)
## magnet_forearm_x < -188.5 to the right, improve=146.4507, (0 missing)
## accel_forearm_x < -70.5 to the right, improve=144.7157, (0 missing)
## Surrogate splits:
## accel_belt_z < -159.5 to the left, agree=0.900, adj=0.572, (0 split)
## total_accel_belt < 17.5 to the right, agree=0.882, adj=0.495, (0 split)
## magnet_belt_x < 165.5 to the right, agree=0.839, adj=0.316, (0 split)
## yaw_dumbbell < -95.52705 to the left, agree=0.816, adj=0.216, (0 split)
## magnet_forearm_x < 624.5 to the right, agree=0.814, adj=0.206, (0 split)
##
## Node number 666: 652 observations, complexity param=0.01898794
## predicted class=C expected loss=0.4003067 P(node) =0.0442995
## class counts: 238 11 391 9 3
## probabilities: 0.365 0.017 0.600 0.014 0.005
## left son=1332 (209 obs) right son=1333 (443 obs)
## Primary splits:
## magnet_belt_z < -323.5 to the left, improve=218.6271, (0 missing)
## pitch_belt < -40.45 to the right, improve=201.6756, (0 missing)
## magnet_dumbbell_z < 24.5 to the left, improve=189.0210, (0 missing)
## roll_belt < 128.5 to the right, improve=166.3526, (0 missing)
## magnet_forearm_x < 263.5 to the right, improve=132.3928, (0 missing)
## Surrogate splits:
## roll_belt < 128.5 to the right, agree=0.926, adj=0.770, (0 split)
## pitch_belt < -40.45 to the right, agree=0.923, adj=0.761, (0 split)
## accel_belt_z < -164.5 to the left, agree=0.888, adj=0.651, (0 split)
## accel_forearm_y < 255.5 to the left, agree=0.887, adj=0.646, (0 split)
## magnet_forearm_x < 263.5 to the right, agree=0.887, adj=0.646, (0 split)
##
## Node number 667: 2126 observations, complexity param=0.01063325
## predicted class=D expected loss=0.6058325 P(node) =0.144449
## class counts: 410 331 261 838 286
## probabilities: 0.193 0.156 0.123 0.394 0.135
## left son=1334 (1344 obs) right son=1335 (782 obs)
## Primary splits:
## pitch_belt < 1.04 to the right, improve=154.2258, (0 missing)
## yaw_belt < -87.05 to the left, improve=145.1140, (0 missing)
## gyros_belt_z < -0.105 to the right, improve=128.2870, (0 missing)
## accel_dumbbell_z < 27.5 to the left, improve=125.4258, (0 missing)
## accel_belt_z < -2.5 to the right, improve=121.3720, (0 missing)
## Surrogate splits:
## accel_belt_x < -0.5 to the left, agree=0.939, adj=0.834, (0 split)
## yaw_belt < -85.55 to the left, agree=0.924, adj=0.793, (0 split)

```

```

##      magnet_belt_x < 77.5      to the left,  agree=0.924, adj=0.793, (0 split)
##      gyros_belt_z  < -0.105   to the right, agree=0.903, adj=0.735, (0 split)
##      accel_belt_z  < -7.5     to the right, agree=0.897, adj=0.721, (0 split)
##
## Node number 1332: 209 observations
##   predicted class=A  expected loss=0.02870813  P(node) =0.0142003
##   class counts:    203      0      3      0      3
##   probabilities: 0.971 0.000 0.014 0.000 0.014
##
## Node number 1333: 443 observations
##   predicted class=C  expected loss=0.1241535  P(node) =0.0300992
##   class counts:     35     11    388      9      0
##   probabilities: 0.079 0.025 0.876 0.020 0.000
##
## Node number 1334: 1344 observations,      complexity param=0.01063325
##   predicted class=B  expected loss=0.764881  P(node) =0.09131675
##   class counts:     308    316    175    291    254
##   probabilities: 0.229 0.235 0.130 0.217 0.189
##   left son=2668 (846 obs) right son=2669 (498 obs)
##   Primary splits:
##     accel_dumbbell_z < 27.5      to the left,  improve=117.73090, (0 missing)
##     yaw_forearm      < -94.65    to the right, improve=102.87940, (0 missing)
##     magnet_forearm_z < -56.5     to the right, improve= 86.79337, (0 missing)
##     yaw_belt         < -93.25    to the right, improve= 82.22818, (0 missing)
##     pitch_forearm    < 3.805     to the left,  improve= 81.91731, (0 missing)
##   Surrogate splits:
##     magnet_dumbbell_z < 334.5    to the left,  agree=0.825, adj=0.528, (0 split)
##     accel_dumbbell_x  < 13.5     to the left,  agree=0.804, adj=0.472, (0 split)
##     yaw_dumbbell      < 55.59403 to the left,  agree=0.795, adj=0.446, (0 split)
##     gyros_dumbbell_x  < -0.215   to the right, agree=0.783, adj=0.414, (0 split)
##     total_accel_dumbbell < 5.5    to the left,  agree=0.774, adj=0.390, (0 split)
##
## Node number 1335: 782 observations
##   predicted class=D  expected loss=0.3005115  P(node) =0.05313222
##   class counts:     102     15     86    547     32
##   probabilities: 0.130 0.019 0.110 0.699 0.041
##
## Node number 2668: 846 observations,      complexity param=0.01063325
##   predicted class=A  expected loss=0.6560284  P(node) =0.05748064
##   class counts:     291    128    172    225     30
##   probabilities: 0.344 0.151 0.203 0.266 0.035
##   left son=5336 (618 obs) right son=5337 (228 obs)
##   Primary splits:
##     yaw_forearm      < -94.65    to the right, improve=122.90840, (0 missing)
##     magnet_dumbbell_y < 263.5    to the right, improve=102.14100, (0 missing)
##     magnet_forearm_z < -174      to the right, improve= 96.96084, (0 missing)
##     accel_forearm_x  < -3.5      to the right, improve= 91.84190, (0 missing)
##     pitch_forearm    < 22.9      to the left,  improve= 89.29766, (0 missing)
##   Surrogate splits:
##     yaw_belt         < -93.15    to the right, agree=0.859, adj=0.478, (0 split)
##     accel_forearm_x  < -106.5     to the right, agree=0.852, adj=0.452, (0 split)
##     pitch_forearm    < 28.75     to the left,  agree=0.845, adj=0.425, (0 split)
##     accel_forearm_z  < -162.5    to the right, agree=0.824, adj=0.346, (0 split)
##     magnet_belt_x    < 7.5       to the right, agree=0.817, adj=0.320, (0 split)

```

```

##
## Node number 2669: 498 observations,      complexity param=0.01044337
## predicted class=E expected loss=0.5502008 P(node) =0.03383612
## class counts:      17   188     3    66   224
## probabilities: 0.034 0.378 0.006 0.133 0.450
## left son=5338 (310 obs) right son=5339 (188 obs)
## Primary splits:
## roll_dumbbell < 53.36059 to the left, improve=80.46827, (0 missing)
## magnet_belt_x < 43.5 to the left, improve=53.16063, (0 missing)
## yaw_belt < -88.15 to the left, improve=47.82673, (0 missing)
## yaw_dumbbell < 101.1489 to the right, improve=34.62069, (0 missing)
## yaw_forearm < 115.5 to the left, improve=34.37824, (0 missing)
## Surrogate splits:
## yaw_dumbbell < 101.1489 to the right, agree=0.819, adj=0.521, (0 split)
## accel_dumbbell_y < 66.5 to the left, agree=0.767, adj=0.383, (0 split)
## gyros_dumbbell_z < 0.04 to the left, agree=0.705, adj=0.218, (0 split)
## accel_forearm_y < 253.5 to the right, agree=0.701, adj=0.207, (0 split)
## accel_dumbbell_z < 41.5 to the right, agree=0.693, adj=0.186, (0 split)
##
## Node number 5336: 618 observations,      complexity param=0.01063325
## predicted class=A expected loss=0.5291262 P(node) =0.0419894
## class counts:      291   119   137    48    23
## probabilities: 0.471 0.193 0.222 0.078 0.037
## left son=10672 (382 obs) right son=10673 (236 obs)
## Primary splits:
## magnet_forearm_z < -68.5 to the right, improve=116.49450, (0 missing)
## magnet_dumbbell_y < 263.5 to the right, improve= 94.66525, (0 missing)
## accel_forearm_y < 238 to the left, improve= 88.68775, (0 missing)
## total_accel_forearm < 36.5 to the left, improve= 87.29102, (0 missing)
## magnet_forearm_y < 811 to the left, improve= 84.16128, (0 missing)
## Surrogate splits:
## magnet_forearm_y < 811 to the left, agree=0.874, adj=0.669, (0 split)
## magnet_dumbbell_y < 238.5 to the right, agree=0.871, adj=0.661, (0 split)
## roll_forearm < -168.5 to the right, agree=0.866, adj=0.648, (0 split)
## accel_forearm_z < 179.5 to the left, agree=0.832, adj=0.559, (0 split)
## accel_forearm_y < 261.5 to the left, agree=0.812, adj=0.508, (0 split)
##
## Node number 5337: 228 observations
## predicted class=D expected loss=0.2236842 P(node) =0.01549124
## class counts:      0     9    35   177     7
## probabilities: 0.000 0.039 0.154 0.776 0.031
##
## Node number 5338: 310 observations
## predicted class=B expected loss=0.4483871 P(node) =0.02106264
## class counts:      16   171     3    59    61
## probabilities: 0.052 0.552 0.010 0.190 0.197
##
## Node number 5339: 188 observations
## predicted class=E expected loss=0.1329787 P(node) =0.01277347
## class counts:      1    17     0     7   163
## probabilities: 0.005 0.090 0.000 0.037 0.867
##
## Node number 10672: 382 observations
## predicted class=A expected loss=0.2670157 P(node) =0.02595461

```

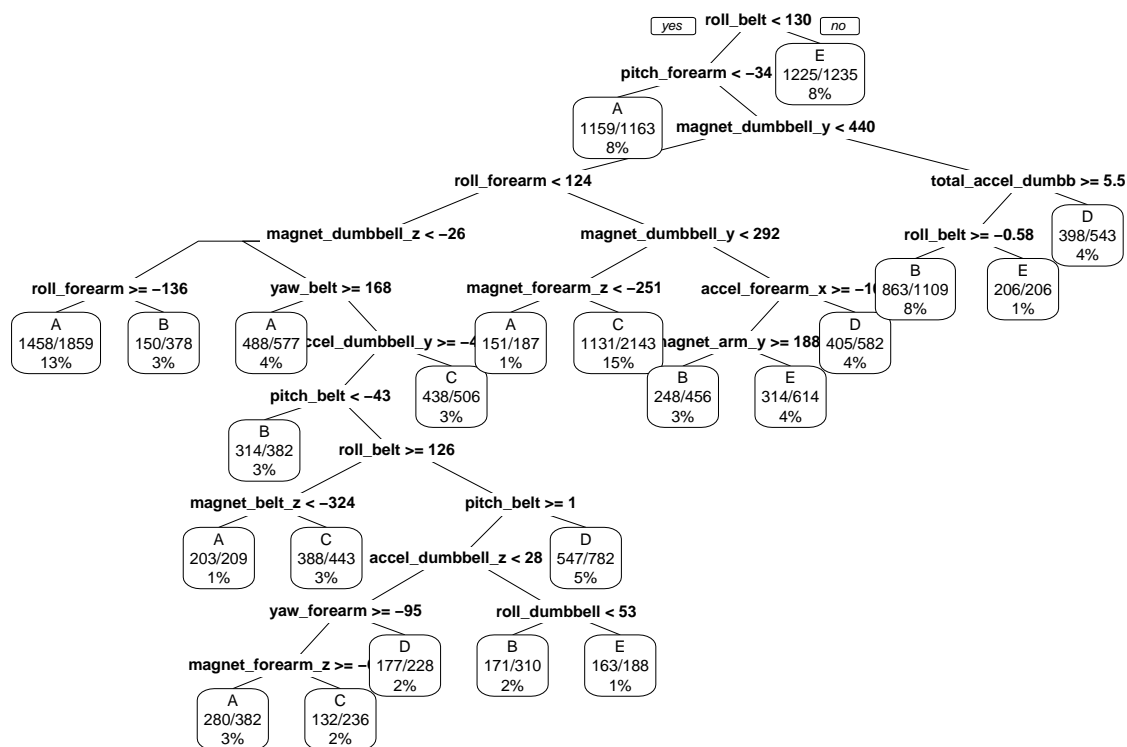
```
##      class counts:   280    52    5    39    6
##      probabilities: 0.733 0.136 0.013 0.102 0.016
##
## Node number 10673: 236 observations
##      predicted class=C expected loss=0.440678 P(node) =0.01603479
##      class counts:    11    67   132    9   17
##      probabilities: 0.047 0.284 0.559 0.038 0.072
```

Predicting using subTesting data

```
prediction <- predict(decisiontreemodel, subTesting, type = "class")
```

Plot of the Decision Tree: decisiontreemodel1

```
prp(decisiontreemodel, faclen = 0, cex = 0.5, extra = 102, xsep="/")
```



Test the results (prediction) on our subTesting data set with confusionMatrix
`confusionMatrix(prediction, subTesting$class)`

```
## Confusion Matrix and Statistics
```

```
##
##      Reference
## Prediction  A    B    C    D    E
##      A 1235  157   16   50   20
##      B   55  568   73   80  102
##      C   44  125  690  118  116
##      D   41   64   50  508   38
##      E   20   35   26   48  625
##
```

```
## Overall Statistics
##
##           Accuracy : 0.7394
##           95% CI : (0.7269, 0.7516)
##       No Information Rate : 0.2845
##       P-Value [Acc > NIR] : < 2.2e-16
##
##           Kappa : 0.6697
##  McNemar's Test P-Value : < 2.2e-16
##
## Statistics by Class:
##
##           Class: A Class: B Class: C Class: D Class: E
## Sensitivity      0.8853  0.5985  0.8070  0.6318  0.6937
## Specificity      0.9307  0.9216  0.9005  0.9529  0.9678
## Pos Pred Value   0.8356  0.6469  0.6313  0.7247  0.8289
## Neg Pred Value   0.9533  0.9054  0.9567  0.9296  0.9335
## Prevalence       0.2845  0.1935  0.1743  0.1639  0.1837
## Detection Rate   0.2518  0.1158  0.1407  0.1036  0.1274
## Detection Prevalence 0.3014  0.1790  0.2229  0.1429  0.1538
## Balanced Accuracy 0.9080  0.7601  0.8537  0.7924  0.8307
```

RESULTS of Decision tree Model: Results from confusionMatrix reported prediction accuracy 0.7372 (95%

4b. Second Prediction model with RandomForests

```
# Using RandomForest
rftreemodel <- randomForest(classe ~ ., data=subTraining, method="class")

# Predicting using subTesting data
prediction1 <- predict(rftreemodel, subTesting, type = "class")

# Test results on subTesting data set:
confusionMatrix(prediction1, subTesting$classe)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  A    B    C    D    E
## A 1395     3    0    0    0
## B    0   943   10    0    0
## C    0    3   844    5    0
## D    0    0    1   799    0
## E    0    0    0    0   901
##
## Overall Statistics
##
##           Accuracy : 0.9955
##           95% CI : (0.9932, 0.9972)
##       No Information Rate : 0.2845
##       P-Value [Acc > NIR] : < 2.2e-16
##
```

```
## Kappa : 0.9943
```

```
## McNemar's Test P-Value : NA
```

```
##
```

```
## Statistics by Class:
```

```
##
```

	Class: A	Class: B	Class: C	Class: D	Class: E
## Sensitivity	1.0000	0.9937	0.9871	0.9938	1.0000
## Specificity	0.9991	0.9975	0.9980	0.9998	1.0000
## Pos Pred Value	0.9979	0.9895	0.9906	0.9988	1.0000
## Neg Pred Value	1.0000	0.9985	0.9973	0.9988	1.0000
## Prevalence	0.2845	0.1935	0.1743	0.1639	0.1837
## Detection Rate	0.2845	0.1923	0.1721	0.1629	0.1837
## Detection Prevalence	0.2851	0.1943	0.1737	0.1631	0.1837
## Balanced Accuracy	0.9996	0.9956	0.9926	0.9968	1.0000

```
# Results from confusionMatrix reported prediction accuracy 0.9947 (95% CI 0.9922, 0.9965)
```

```
# **RESULT**: When comparing the RESULTS from rpart (decision tree) and RandomForest Model), RandomForest
```

```
# The given test dataset comprises 53 variables and 20 obs. With a prediction accuracy of RandomForest
```

```
# predict outcome levels on the main Testing dataset using Random Forest algorithm
```

```
predictionfinal <- predict(rftreemodel, testdataset, type="class")
```

```
# plot prediction final results
```

```
plot(predictionfinal)
```

