

Project

Kexin Jin

2/18/2020

Background

Using devices such as Jawbone Up, Nike FuelBand, and Fitbit it is now possible to collect a large amount of data about personal activity relatively inexpensively. These type of devices are part of the quantified self movement – a group of enthusiasts who take measurements about themselves regularly to improve their health, to find patterns in their behavior, or because they are tech geeks. One thing that people regularly do is quantify how much of a particular activity they do, but they rarely quantify how well they do it. In this project, your goal will be to use data from accelerometers on the belt, forearm, arm, and dumbbell of 6 participants. They were asked to perform barbell lifts correctly and incorrectly in 5 different ways. More information is available from the website here: <http://groupware.les.inf.puc-rio.br/har> (see the section on the Weight Lifting Exercise Dataset).

Data

The training data for this project are available here:

<https://d396qusza40orc.cloudfront.net/predmachlearn/pml-training.csv>

The test data are available here:

<https://d396qusza40orc.cloudfront.net/predmachlearn/pml-testing.csv>

The data for this project come from this source: <http://groupware.les.inf.puc-rio.br/har>. If you use the document you create for this class for any purpose please cite them as they have been very generous in allowing their data to be used for this kind of assignment.

Introduction to the data from its website:"

Six young health participants were asked to perform one set of 10 repetitions of the Unilateral Dumbbell Biceps Curl in five different fashions: exactly according to the specification (Class A), throwing the elbows to the front (Class B), lifting the dumbbell only halfway (Class C), lowering the dumbbell only halfway (Class D) and throwing the hips to the front (Class E).

Class A corresponds to the specified execution of the exercise, while the other 4 classes correspond to common mistakes. Participants were supervised by an experienced weight lifter to make sure the execution complied to the manner they were supposed to simulate. The exercises were performed by six male participants aged between 20-28 years, with little weight lifting experience. We made sure that all participants could easily simulate the mistakes in a safe and controlled manner by using a relatively light dumbbell (1.25kg).

"

What you should submit

The goal of your project is to predict the manner in which they did the exercise. This is the “classe” variable in the training set. You may use any of the other variables to predict with. You should create a report describing how you built your model, how you used cross validation, what you think the expected out of sample error is, and why you made the choices you did. You will also use your prediction model to predict 20 different test cases.

Peer Review Portion

Your submission for the Peer Review portion should consist of a link to a Github repo with your R markdown and compiled HTML file describing your analysis. Please constrain the text of the writeup to < 2000 words and the number of figures to be less than 5. It will make it easier for the graders if you submit a repo with a gh-pages branch so the HTML page can be viewed online (and you always want to make it easy on graders :-).

Course Project Prediction Quiz Portion

Apply your machine learning algorithm to the 20 test cases available in the test data above and submit your predictions in appropriate format to the Course Project Prediction Quiz for automated grading.

Reproducibility

Due to security concerns with the exchange of R code, your code will not be run during the evaluation by your classmates. Please be sure that if they download the repo, they will be able to view the compiled HTML version of your analysis.

Load the data

```
knitr::opts_chunk$set(echo = TRUE)
url<-"https://d396qusza40orc.cloudfront.net/predmachlearn/pml-training.csv"
download.file(url, destfile = "/Volumes/GoogleDrive/My Drive/13Knowledge/DataScience/JhuDS/08Practical Machine Learning/pml-training.csv")
url<-"https://d396qusza40orc.cloudfront.net/predmachlearn/pml-testing.csv"
download.file(url, destfile = "/Volumes/GoogleDrive/My Drive/13Knowledge/DataScience/JhuDS/08Practical Machine Learning/pml-testing.csv")
data0<-read.csv(file = "/Volumes/GoogleDrive/My Drive/13Knowledge/DataScience/JhuDS/08Practical Machine Learning/pml-training.csv")
coursera0<-read.csv(file = "/Volumes/GoogleDrive/My Drive/13Knowledge/DataScience/JhuDS/08Practical Machine Learning/pml-testing.csv")
dim(data0)

## [1] 19622 160
dim(coursera0)

## [1] 20 160
summary(data0)

##           X           user_name raw_timestamp_part_1 raw_timestamp_part_2
## Min.      :    1      adelmo :3892      Min.      :1.322e+09      Min.      :    294
## 1st Qu.: 4906      carlitos:3112      1st Qu.:1.323e+09      1st Qu.:252912
## Median : 9812      charles :3536      Median :1.323e+09      Median :496380
## Mean    : 9812      eurico  :3070      Mean    :1.323e+09      Mean    :500656
## 3rd Qu.:14717      jeremy  :3402      3rd Qu.:1.323e+09      3rd Qu.:751891
## Max.    :19622      pedro  :2610      Max.    :1.323e+09      Max.    :998801
##
##           cvtd_timestamp new_window num_window roll_belt
## 28/11/2011 14:14: 1498 no :19216      Min.      :    1.0      Min.      : -28.90
## 05/12/2011 11:24: 1497 yes: 406      1st Qu.:222.0      1st Qu.:    1.10
## 30/11/2011 17:11: 1440              Median :424.0      Median :   113.00
## 05/12/2011 11:25: 1425              Mean   :430.6      Mean    :    64.41
## 02/12/2011 14:57: 1380              3rd Qu.:644.0      3rd Qu.:   123.00
## 02/12/2011 13:34: 1375              Max.    :864.0      Max.    :   162.00
## (Other)           :11007
##           pitch_belt      yaw_belt      total_accel_belt kurtosis_roll_belt
## Min.      : -55.8000      Min.      : -180.00      Min.      :    0.00              :19216
```

```

## 1st Qu.: 1.7600 1st Qu.: -88.30 1st Qu.: 3.00 #DIV/0! : 10
## Median : 5.2800 Median : -13.00 Median :17.00 -1.908453: 2
## Mean : 0.3053 Mean : -11.21 Mean :11.31 -0.016850: 1
## 3rd Qu.: 14.9000 3rd Qu.: 12.90 3rd Qu.:18.00 -0.021024: 1
## Max. : 60.3000 Max. : 179.00 Max. :29.00 -0.025513: 1
## (Other) : 391
## kurtosis_picth_belt kurtosis_yaw_belt skewness_roll_belt
## :19216 :19216 :19216
## #DIV/0! : 32 #DIV/0!: 406 #DIV/0! : 9
## 47.000000: 4 0.000000 : 4
## -0.150950: 3 0.422463 : 2
## -0.684748: 3 -0.003095: 1
## -1.750749: 3 -0.010002: 1
## (Other) : 361 (Other) : 389
## skewness_roll_belt.1 skewness_yaw_belt max_roll_belt max_picth_belt
## :19216 :19216 Min. : -94.300 Min. : 3.00
## #DIV/0! : 32 #DIV/0!: 406 1st Qu.: -88.000 1st Qu.: 5.00
## 0.000000 : 4 Median : -5.100 Median :18.00
## -2.156553: 3 Mean : -6.667 Mean :12.92
## -3.072669: 3 3rd Qu.: 18.500 3rd Qu.:19.00
## -6.324555: 3 Max. :180.000 Max. :30.00
## (Other) : 361 NA's :19216 NA's :19216
## max_yaw_belt min_roll_belt min_pitch_belt min_yaw_belt
## :19216 Min. : -180.00 Min. : 0.00 :19216
## -1.1 : 30 1st Qu.: -88.40 1st Qu.: 3.00 -1.1 : 30
## -1.4 : 29 Median : -7.85 Median :16.00 -1.4 : 29
## -1.2 : 26 Mean : -10.44 Mean :10.76 -1.2 : 26
## -0.9 : 24 3rd Qu.: 9.05 3rd Qu.:17.00 -0.9 : 24
## -1.3 : 22 Max. : 173.00 Max. :23.00 -1.3 : 22
## (Other): 275 NA's :19216 NA's :19216 (Other): 275
## amplitude_roll_belt amplitude_pitch_belt amplitude_yaw_belt
## Min. : 0.000 Min. : 0.000 :19216
## 1st Qu.: 0.300 1st Qu.: 1.000 #DIV/0!: 10
## Median : 1.000 Median : 1.000 0.00 : 12
## Mean : 3.769 Mean : 2.167 0.0000 : 384
## 3rd Qu.: 2.083 3rd Qu.: 2.000
## Max. :360.000 Max. :12.000
## NA's :19216 NA's :19216
## var_total_accel_belt avg_roll_belt stddev_roll_belt var_roll_belt
## Min. : 0.000 Min. : -27.40 Min. : 0.000 Min. : 0.000
## 1st Qu.: 0.100 1st Qu.: 1.10 1st Qu.: 0.200 1st Qu.: 0.000
## Median : 0.200 Median :116.35 Median : 0.400 Median : 0.100
## Mean : 0.926 Mean : 68.06 Mean : 1.337 Mean : 7.699
## 3rd Qu.: 0.300 3rd Qu.:123.38 3rd Qu.: 0.700 3rd Qu.: 0.500
## Max. :16.500 Max. :157.40 Max. :14.200 Max. :200.700
## NA's :19216 NA's :19216 NA's :19216 NA's :19216
## avg_pitch_belt stddev_pitch_belt var_pitch_belt avg_yaw_belt
## Min. : -51.400 Min. :0.000 Min. : 0.000 Min. : -138.300
## 1st Qu.: 2.025 1st Qu.:0.200 1st Qu.: 0.000 1st Qu.: -88.175
## Median : 5.200 Median :0.400 Median : 0.100 Median : -6.550
## Mean : 0.520 Mean :0.603 Mean : 0.766 Mean : -8.831
## 3rd Qu.: 15.775 3rd Qu.:0.700 3rd Qu.: 0.500 3rd Qu.: 14.125
## Max. : 59.700 Max. :4.000 Max. :16.200 Max. : 173.500
## NA's :19216 NA's :19216 NA's :19216 NA's :19216

```

```

## stddev_yaw_belt      var_yaw_belt      gyros_belt_x
## Min.   : 0.000      Min.   : 0.000      Min.   : -1.040000
## 1st Qu.: 0.100      1st Qu.: 0.010      1st Qu.: -0.030000
## Median : 0.300      Median : 0.090      Median : 0.030000
## Mean   : 1.341      Mean   : 107.487     Mean   : -0.005592
## 3rd Qu.: 0.700      3rd Qu.: 0.475      3rd Qu.: 0.110000
## Max.   :176.600     Max.   :31183.240    Max.   : 2.220000
## NA's   :19216      NA's   :19216
## gyros_belt_y      gyros_belt_z      accel_belt_x      accel_belt_y
## Min.   : -0.64000   Min.   : -1.4600    Min.   : -120.000   Min.   : -69.00
## 1st Qu.: 0.00000    1st Qu.: -0.2000    1st Qu.: -21.000    1st Qu.: 3.00
## Median : 0.02000    Median : -0.1000    Median : -15.000    Median : 35.00
## Mean   : 0.03959    Mean   : -0.1305    Mean   : -5.595     Mean   : 30.15
## 3rd Qu.: 0.11000    3rd Qu.: -0.0200    3rd Qu.: -5.000     3rd Qu.: 61.00
## Max.   : 0.64000    Max.   : 1.6200     Max.   : 85.000     Max.   :164.00
##
## accel_belt_z      magnet_belt_x      magnet_belt_y      magnet_belt_z
## Min.   : -275.00    Min.   : -52.0      Min.   :354.0       Min.   : -623.0
## 1st Qu.: -162.00    1st Qu.: 9.0        1st Qu.:581.0       1st Qu.: -375.0
## Median : -152.00    Median : 35.0       Median :601.0       Median : -320.0
## Mean   : -72.59     Mean   : 55.6       Mean   :593.7       Mean   : -345.5
## 3rd Qu.: 27.00     3rd Qu.: 59.0      3rd Qu.:610.0       3rd Qu.: -306.0
## Max.   : 105.00     Max.   :485.0       Max.   :673.0       Max.   : 293.0
##
## roll_arm      pitch_arm      yaw_arm      total_accel_arm
## Min.   : -180.00    Min.   : -88.800    Min.   : -180.0000   Min.   : 1.00
## 1st Qu.: -31.77     1st Qu.: -25.900    1st Qu.: -43.1000    1st Qu.:17.00
## Median : 0.00       Median : 0.000      Median : 0.0000      Median :27.00
## Mean   : 17.83      Mean   : -4.612     Mean   : -0.6188     Mean   :25.51
## 3rd Qu.: 77.30     3rd Qu.: 11.200    3rd Qu.: 45.8750     3rd Qu.:33.00
## Max.   : 180.00     Max.   : 88.500     Max.   : 180.0000     Max.   :66.00
##
## var_accel_arm      avg_roll_arm      stddev_roll_arm      var_roll_arm
## Min.   : 0.00       Min.   : -166.67    Min.   : 0.000      Min.   : 0.000
## 1st Qu.: 9.03       1st Qu.: -38.37    1st Qu.: 1.376     1st Qu.: 1.898
## Median : 40.61      Median : 0.00       Median : 5.702     Median : 32.517
## Mean   : 53.23      Mean   : 12.68      Mean   : 11.201     Mean   : 417.264
## 3rd Qu.: 75.62     3rd Qu.: 76.33    3rd Qu.: 14.921    3rd Qu.: 222.647
## Max.   :331.70     Max.   : 163.33    Max.   :161.964     Max.   :26232.208
## NA's   :19216      NA's   :19216      NA's   :19216      NA's   :19216
## avg_pitch_arm      stddev_pitch_arm      var_pitch_arm      avg_yaw_arm
## Min.   : -81.773    Min.   : 0.000      Min.   : 0.000      Min.   : -173.440
## 1st Qu.: -22.770    1st Qu.: 1.642     1st Qu.: 2.697     1st Qu.: -29.198
## Median : 0.000      Median : 8.133     Median : 66.146     Median : 0.000
## Mean   : -4.901     Mean   :10.383     Mean   : 195.864     Mean   : 2.359
## 3rd Qu.: 8.277      3rd Qu.:16.327    3rd Qu.: 266.576    3rd Qu.: 38.185
## Max.   : 75.659     Max.   :43.412     Max.   :1884.565     Max.   : 152.000
## NA's   :19216      NA's   :19216      NA's   :19216      NA's   :19216
## stddev_yaw_arm      var_yaw_arm      gyros_arm_x
## Min.   : 0.000      Min.   : 0.000      Min.   : -6.37000
## 1st Qu.: 2.577      1st Qu.: 6.642     1st Qu.: -1.33000
## Median : 16.682     Median : 278.309    Median : 0.08000
## Mean   : 22.270     Mean   :1055.933    Mean   : 0.04277
## 3rd Qu.: 35.984     3rd Qu.:1294.850    3rd Qu.: 1.57000

```

```

## Max. :177.044 Max. :31344.568 Max. : 4.87000
## NA's :19216 NA's :19216
## gyros_arm_y gyros_arm_z accel_arm_x accel_arm_y
## Min. :-3.4400 Min. :-2.3300 Min. :-404.00 Min. :-318.0
## 1st Qu.:-0.8000 1st Qu.:-0.0700 1st Qu.:-242.00 1st Qu.: -54.0
## Median :-0.2400 Median : 0.2300 Median : -44.00 Median : 14.0
## Mean :-0.2571 Mean : 0.2695 Mean : -60.24 Mean : 32.6
## 3rd Qu.: 0.1400 3rd Qu.: 0.7200 3rd Qu.: 84.00 3rd Qu.: 139.0
## Max. : 2.8400 Max. : 3.0200 Max. : 437.00 Max. : 308.0
##
## accel_arm_z magnet_arm_x magnet_arm_y magnet_arm_z
## Min. :-636.00 Min. :-584.0 Min. :-392.0 Min. :-597.0
## 1st Qu.:-143.00 1st Qu.:-300.0 1st Qu.: -9.0 1st Qu.: 131.2
## Median : -47.00 Median : 289.0 Median : 202.0 Median : 444.0
## Mean : -71.25 Mean : 191.7 Mean : 156.6 Mean : 306.5
## 3rd Qu.: 23.00 3rd Qu.: 637.0 3rd Qu.: 323.0 3rd Qu.: 545.0
## Max. : 292.00 Max. : 782.0 Max. : 583.0 Max. : 694.0
##
## kurtosis_roll_arm kurtosis_pitch_arm kurtosis_yaw_arm skewness_roll_arm
## :19216 :19216 :19216 :19216
## #DIV/0! : 78 #DIV/0! : 80 #DIV/0! : 11 #DIV/0! : 77
## -0.02438: 1 -0.00484: 1 0.55844 : 2 -0.00051: 1
## -0.04190: 1 -0.01311: 1 0.65132 : 2 -0.00696: 1
## -0.05051: 1 -0.02967: 1 -0.01548: 1 -0.01884: 1
## -0.05695: 1 -0.07394: 1 -0.01749: 1 -0.03359: 1
## (Other) : 324 (Other) : 322 (Other) : 389 (Other) : 325
## skewness_pitch_arm skewness_yaw_arm max_roll_arm max_pitch_arm
## :19216 :19216 Min. :-73.100 Min. :-173.000
## #DIV/0! : 80 #DIV/0! : 11 1st Qu.: -0.175 1st Qu.: -1.975
## -0.00184: 1 -1.62032: 2 Median : 4.950 Median : 23.250
## -0.01185: 1 0.55053 : 2 Mean : 11.236 Mean : 35.751
## -0.01247: 1 -0.00311: 1 3rd Qu.: 26.775 3rd Qu.: 95.975
## -0.02063: 1 -0.00562: 1 Max. : 85.500 Max. : 180.000
## (Other) : 322 (Other) : 389 NA's :19216 NA's :19216
## max_yaw_arm min_roll_arm min_pitch_arm min_yaw_arm
## Min. : 4.00 Min. :-89.10 Min. :-180.00 Min. : 1.00
## 1st Qu.:29.00 1st Qu.: -41.98 1st Qu.: -72.62 1st Qu.: 8.00
## Median :34.00 Median :-22.45 Median : -33.85 Median :13.00
## Mean :35.46 Mean :-21.22 Mean : -33.92 Mean :14.66
## 3rd Qu.:41.00 3rd Qu.: 0.00 3rd Qu.: 0.00 3rd Qu.:19.00
## Max. :65.00 Max. : 66.40 Max. : 152.00 Max. :38.00
## NA's :19216 NA's :19216 NA's :19216 NA's :19216
## amplitude_roll_arm amplitude_pitch_arm amplitude_yaw_arm
## Min. : 0.000 Min. : 0.000 Min. : 0.00
## 1st Qu.: 5.425 1st Qu.: 9.925 1st Qu.:13.00
## Median : 28.450 Median : 54.900 Median :22.00
## Mean : 32.452 Mean : 69.677 Mean :20.79
## 3rd Qu.: 50.960 3rd Qu.:115.175 3rd Qu.:28.75
## Max. :119.500 Max. :360.000 Max. :52.00
## NA's :19216 NA's :19216 NA's :19216
## roll_dumbbell pitch_dumbbell yaw_dumbbell
## Min. :-153.71 Min. :-149.59 Min. :-150.871
## 1st Qu.: -18.49 1st Qu.: -40.89 1st Qu.: -77.644
## Median : 48.17 Median : -20.96 Median : -3.324

```

```

## Mean : 23.84 Mean : -10.78 Mean : 1.674
## 3rd Qu.: 67.61 3rd Qu.: 17.50 3rd Qu.: 79.643
## Max. : 153.55 Max. : 149.40 Max. : 154.952
##
## kurtosis_roll_dumbbell kurtosis_pitch_dumbbell kurtosis_yaw_dumbbell
## :19216 :19216 :19216
## #DIV/0!: 5 -0.5464: 2 #DIV/0!: 406
## -0.2583: 2 -0.9334: 2
## -0.3705: 2 -2.0833: 2
## -0.5855: 2 -2.0851: 2
## -2.0851: 2 -2.0889: 2
## (Other): 393 (Other): 396
## skewness_roll_dumbbell skewness_pitch_dumbbell skewness_yaw_dumbbell
## :19216 :19216 :19216
## #DIV/0!: 4 -0.2328: 2 #DIV/0!: 406
## -0.9324: 2 -0.3521: 2
## 0.1110 : 2 -0.7036: 2
## 1.0312 : 2 0.1090 : 2
## -0.0082: 1 1.0326 : 2
## (Other): 395 (Other): 396
## max_roll_dumbbell max_pitch_dumbbell max_yaw_dumbbell min_roll_dumbbell
## Min. : -70.10 Min. : -112.90 :19216 Min. : -149.60
## 1st Qu.: -27.15 1st Qu.: -66.70 -0.6 : 20 1st Qu.: -59.67
## Median : 14.85 Median : 40.05 0.2 : 19 Median : -43.55
## Mean : 13.76 Mean : 32.75 -0.8 : 18 Mean : -41.24
## 3rd Qu.: 50.58 3rd Qu.: 133.22 -0.3 : 16 3rd Qu.: -25.20
## Max. : 137.00 Max. : 155.00 -0.2 : 15 Max. : 73.20
## NA's :19216 NA's :19216 (Other): 318 NA's :19216
## min_pitch_dumbbell min_yaw_dumbbell amplitude_roll_dumbbell
## Min. : -147.00 :19216 Min. : 0.00
## 1st Qu.: -91.80 -0.6 : 20 1st Qu.: 14.97
## Median : -66.15 0.2 : 19 Median : 35.05
## Mean : -33.18 -0.8 : 18 Mean : 55.00
## 3rd Qu.: 21.20 -0.3 : 16 3rd Qu.: 81.04
## Max. : 120.90 -0.2 : 15 Max. : 256.48
## NA's :19216 (Other): 318 NA's :19216
## amplitude_pitch_dumbbell amplitude_yaw_dumbbell total_accel_dumbbell
## Min. : 0.00 :19216 Min. : 0.00
## 1st Qu.: 17.06 #DIV/0!: 5 1st Qu.: 4.00
## Median : 41.73 0.00 : 401 Median : 10.00
## Mean : 65.93 Mean : 13.72
## 3rd Qu.: 99.55 3rd Qu.: 19.00
## Max. : 273.59 Max. : 58.00
## NA's :19216
## var_accel_dumbbell avg_roll_dumbbell stddev_roll_dumbbell
## Min. : 0.000 Min. : -128.96 Min. : 0.000
## 1st Qu.: 0.378 1st Qu.: -12.33 1st Qu.: 4.639
## Median : 1.000 Median : 48.23 Median : 12.204
## Mean : 4.388 Mean : 23.86 Mean : 20.761
## 3rd Qu.: 3.434 3rd Qu.: 64.37 3rd Qu.: 26.356
## Max. : 230.428 Max. : 125.99 Max. : 123.778
## NA's :19216 NA's :19216 NA's :19216
## var_roll_dumbbell avg_pitch_dumbbell stddev_pitch_dumbbell
## Min. : 0.00 Min. : -70.73 Min. : 0.000

```

```

## 1st Qu.: 21.52 1st Qu.: -42.00 1st Qu.: 3.482
## Median : 148.95 Median : -19.91 Median : 8.089
## Mean : 1020.27 Mean : -12.33 Mean : 13.147
## 3rd Qu.: 694.65 3rd Qu.: 13.21 3rd Qu.: 19.238
## Max. : 15321.01 Max. : 94.28 Max. : 82.680
## NA's : 19216 NA's : 19216 NA's : 19216
## var_pitch_dumbbell avg_yaw_dumbbell stddev_yaw_dumbbell
## Min. : 0.00 Min. : -117.950 Min. : 0.000
## 1st Qu.: 12.12 1st Qu.: -76.696 1st Qu.: 3.885
## Median : 65.44 Median : -4.505 Median : 10.264
## Mean : 350.31 Mean : 0.202 Mean : 16.647
## 3rd Qu.: 370.11 3rd Qu.: 71.234 3rd Qu.: 24.674
## Max. : 6836.02 Max. : 134.905 Max. : 107.088
## NA's : 19216 NA's : 19216 NA's : 19216
## var_yaw_dumbbell gyros_dumbbell_x gyros_dumbbell_y
## Min. : 0.00 Min. : -204.0000 Min. : -2.10000
## 1st Qu.: 15.09 1st Qu.: -0.0300 1st Qu.: -0.14000
## Median : 105.35 Median : 0.1300 Median : 0.03000
## Mean : 589.84 Mean : 0.1611 Mean : 0.04606
## 3rd Qu.: 608.79 3rd Qu.: 0.3500 3rd Qu.: 0.21000
## Max. : 11467.91 Max. : 2.2200 Max. : 52.00000
## NA's : 19216
## gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y accel_dumbbell_z
## Min. : -2.380 Min. : -419.00 Min. : -189.00 Min. : -334.00
## 1st Qu.: -0.310 1st Qu.: -50.00 1st Qu.: -8.00 1st Qu.: -142.00
## Median : -0.130 Median : -8.00 Median : 41.50 Median : -1.00
## Mean : -0.129 Mean : -28.62 Mean : 52.63 Mean : -38.32
## 3rd Qu.: 0.030 3rd Qu.: 11.00 3rd Qu.: 111.00 3rd Qu.: 38.00
## Max. : 317.000 Max. : 235.00 Max. : 315.00 Max. : 318.00
##
## magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z roll_forearm
## Min. : -643.0 Min. : -3600 Min. : -262.00 Min. : -180.0000
## 1st Qu.: -535.0 1st Qu.: 231 1st Qu.: -45.00 1st Qu.: -0.7375
## Median : -479.0 Median : 311 Median : 13.00 Median : 21.7000
## Mean : -328.5 Mean : 221 Mean : 46.05 Mean : 33.8265
## 3rd Qu.: -304.0 3rd Qu.: 390 3rd Qu.: 95.00 3rd Qu.: 140.0000
## Max. : 592.0 Max. : 633 Max. : 452.00 Max. : 180.0000
##
## pitch_forearm yaw_forearm kurtosis_roll_forearm
## Min. : -72.50 Min. : -180.00 :19216
## 1st Qu.: 0.00 1st Qu.: -68.60 #DIV/0!: 84
## Median : 9.24 Median : 0.00 -0.8079: 2
## Mean : 10.71 Mean : 19.21 -0.9169: 2
## 3rd Qu.: 28.40 3rd Qu.: 110.00 -0.0227: 1
## Max. : 89.80 Max. : 180.00 -0.0359: 1
## (Other): 316
## kurtosis_pitch_forearm kurtosis_yaw_forearm skewness_roll_forearm
## :19216 :19216 :19216
## #DIV/0!: 85 #DIV/0!: 406 #DIV/0!: 83
## -0.0073: 1 -0.1912: 2
## -0.0442: 1 -0.4126: 2
## -0.0489: 1 -0.0004: 1
## -0.0523: 1 -0.0013: 1
## (Other): 317 (Other): 317

```

```

## skewness_pitch_forearm skewness_yaw_forearm max_roll_forearm
##      :19216      :19216      Min.      :-66.60
## #DIV/0!: 85      #DIV/0!: 406      1st Qu.: 0.00
## 0.0000 : 4      Median : 26.80
## -0.6992: 2      Mean : 24.49
## -0.0113: 1      3rd Qu.: 45.95
## -0.0131: 1      Max. : 89.80
## (Other): 313      NA's :19216
## max_pitch_forearm max_yaw_forearm min_roll_forearm min_pitch_forearm
## Min.      :-151.00      :19216 Min.      :-72.500 Min.      :-180.00
## 1st Qu.: 0.00 #DIV/0!: 84 1st Qu.: -6.075 1st Qu.: -175.00
## Median : 113.00 -1.2 : 32 Median : 0.000 Median : -61.00
## Mean : 81.49 -1.3 : 31 Mean : -0.167 Mean : -57.57
## 3rd Qu.: 174.75 -1.4 : 24 3rd Qu.: 12.075 3rd Qu.: 0.00
## Max. : 180.00 -1.5 : 24 Max. : 62.100 Max. : 167.00
## NA's :19216 (Other): 211 NA's :19216 NA's :19216
## min_yaw_forearm amplitude_roll_forearm amplitude_pitch_forearm
##      :19216 Min. : 0.000 Min. : 0.0
## #DIV/0!: 84 1st Qu.: 1.125 1st Qu.: 2.0
## -1.2 : 32 Median : 17.770 Median : 83.7
## -1.3 : 31 Mean : 24.653 Mean : 139.1
## -1.4 : 24 3rd Qu.: 39.875 3rd Qu.: 350.0
## -1.5 : 24 Max. : 126.000 Max. : 360.0
## (Other): 211 NA's :19216 NA's :19216
## amplitude_yaw_forearm total_accel_forearm var_accel_forearm
##      :19216 Min. : 0.00 Min. : 0.000
## #DIV/0!: 84 1st Qu.: 29.00 1st Qu.: 6.759
## 0.00 : 322 Median : 36.00 Median : 21.165
## Mean : 34.72 Mean : 33.502
## 3rd Qu.: 41.00 3rd Qu.: 51.240
## Max. : 108.00 Max. : 172.606
## NA's :19216
## avg_roll_forearm stddev_roll_forearm var_roll_forearm
## Min.      :-177.234 Min. : 0.000 Min. : 0.00
## 1st Qu.: -0.909 1st Qu.: 0.428 1st Qu.: 0.18
## Median : 11.172 Median : 8.030 Median : 64.48
## Mean : 33.165 Mean : 41.986 Mean : 5274.10
## 3rd Qu.: 107.132 3rd Qu.: 85.373 3rd Qu.: 7289.08
## Max. : 177.256 Max. : 179.171 Max. : 32102.24
## NA's :19216 NA's :19216 NA's :19216
## avg_pitch_forearm stddev_pitch_forearm var_pitch_forearm
## Min.      :-68.17 Min. : 0.000 Min. : 0.000
## 1st Qu.: 0.00 1st Qu.: 0.336 1st Qu.: 0.113
## Median : 12.02 Median : 5.516 Median : 30.425
## Mean : 11.79 Mean : 7.977 Mean : 139.593
## 3rd Qu.: 28.48 3rd Qu.: 12.866 3rd Qu.: 165.532
## Max. : 72.09 Max. : 47.745 Max. : 2279.617
## NA's :19216 NA's :19216 NA's :19216
## avg_yaw_forearm stddev_yaw_forearm var_yaw_forearm gyros_forearm_x
## Min.      :-155.06 Min. : 0.000 Min. : 0.00 Min. : -22.000
## 1st Qu.: -26.26 1st Qu.: 0.524 1st Qu.: 0.27 1st Qu.: -0.220
## Median : 0.00 Median : 24.743 Median : 612.21 Median : 0.050
## Mean : 18.00 Mean : 44.854 Mean : 4639.85 Mean : 0.158
## 3rd Qu.: 85.79 3rd Qu.: 85.817 3rd Qu.: 7368.41 3rd Qu.: 0.560

```



```
## Max. : 169.24 Max. :197.508 Max. :39009.33 Max. : 3.970
## NA's :19216 NA's :19216 NA's :19216
## 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\(coursera0\)](#)

```
## X user_name raw_timestamp_part_1 raw_timestamp_part_2
## Min. : 1.00 adelmo :1 Min. :1.322e+09 Min. : 36553
## 1st Qu.: 5.75 carlitos:3 1st Qu.:1.323e+09 1st Qu.:268655
## Median :10.50 charles :1 Median :1.323e+09 Median :530706
## Mean :10.50 eurico :4 Mean :1.323e+09 Mean :512167
## 3rd Qu.:15.25 jeremy :8 3rd Qu.:1.323e+09 3rd Qu.:787738
## Max. :20.00 pedro :3 Max. :1.323e+09 Max. :920315
##
## cvtd_timestamp new_window num_window roll_belt
## 30/11/2011 17:11:4 no:20 Min. : 48.0 Min. : -5.9200
## 05/12/2011 11:24:3 1st Qu.:250.0 1st Qu.: 0.9075
## 30/11/2011 17:12:3 Median :384.5 Median : 1.1100
## 05/12/2011 14:23:2 Mean :379.6 Mean : 31.3055
## 28/11/2011 14:14:2 3rd Qu.:467.0 3rd Qu.: 32.5050
## 02/12/2011 13:33:1 Max. :859.0 Max. :129.0000
## (Other) :5
## pitch_belt yaw_belt total_accel_belt kurtosis_roll_belt
## Min. : -41.600 Min. : -93.70 Min. : 2.00 Mode:logical
## 1st Qu.: 3.013 1st Qu.: -88.62 1st Qu.: 3.00 NA's:20
## Median : 4.655 Median : -87.85 Median : 4.00
## Mean : 5.824 Mean : -59.30 Mean : 7.55
## 3rd Qu.: 6.135 3rd Qu.: -63.50 3rd Qu.: 8.00
## Max. : 27.800 Max. :162.00 Max. :21.00
##
## kurtosis_picth_belt kurtosis_yaw_belt skewness_roll_belt
## Mode:logical Mode:logical Mode:logical
```

```

## NA's:20          NA's:20          NA's:20
##
##
##
##
## skewness_roll_belt.1 skewness_yaw_belt max_roll_belt max_pitch_belt
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20           NA's:20
##
##
##
##
## max_yaw_belt      min_roll_belt      min_pitch_belt min_yaw_belt
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20           NA's:20
##
##
##
##
## amplitude_roll_belt amplitude_pitch_belt amplitude_yaw_belt
## Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20
##
##
##
##
## var_total_accel_belt avg_roll_belt      stddev_roll_belt var_roll_belt
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20           NA's:20
##
##
##
##
## avg_pitch_belt      stddev_pitch_belt var_pitch_belt avg_yaw_belt
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20           NA's:20
##
##
##
##
## stddev_yaw_belt var_yaw_belt      gyros_belt_x      gyros_belt_y
## Mode:logical      Mode:logical      Min.      :-0.500      Min.      :-0.050
## NA's:20           NA's:20           1st Qu.: -0.070      1st Qu.: -0.005
##                               Median : 0.020      Median : 0.000
##                               Mean   : -0.045      Mean   : 0.010
##                               3rd Qu.: 0.070      3rd Qu.: 0.020
##                               Max.   : 0.240      Max.   : 0.110
##

```

```

## gyros_belt_z accel_belt_x accel_belt_y accel_belt_z
## Min. :-0.4800 Min. :-48.00 Min. :-16.00 Min. :-187.00
## 1st Qu.: -0.1375 1st Qu.: -19.00 1st Qu.: 2.00 1st Qu.: -24.00
## Median : -0.0250 Median : -13.00 Median : 4.50 Median : 27.00
## Mean :-0.1005 Mean :-13.50 Mean : 18.35 Mean : -17.60
## 3rd Qu.: 0.0000 3rd Qu.: -8.75 3rd Qu.: 25.50 3rd Qu.: 38.25
## Max. : 0.0500 Max. : 46.00 Max. : 72.00 Max. : 49.00
##
## magnet_belt_x magnet_belt_y magnet_belt_z roll_arm
## Min. :-13.00 Min. :566.0 Min. :-426.0 Min. :-137.00
## 1st Qu.: 5.50 1st Qu.:578.5 1st Qu.: -398.5 1st Qu.: 0.00
## Median : 33.50 Median :600.5 Median : -313.5 Median : 0.00
## Mean : 35.15 Mean :601.5 Mean : -346.9 Mean : 16.42
## 3rd Qu.: 46.25 3rd Qu.:631.2 3rd Qu.: -305.0 3rd Qu.: 71.53
## Max. :169.00 Max. :638.0 Max. : -291.0 Max. : 152.00
##
## pitch_arm yaw_arm total_accel_arm var_accel_arm
## Min. :-63.800 Min. :-167.00 Min. : 3.00 Mode:logical
## 1st Qu.: -9.188 1st Qu.: -60.15 1st Qu.:20.25 NA's:20
## Median : 0.000 Median : 0.00 Median :29.50
## Mean : -3.950 Mean : -2.80 Mean :26.40
## 3rd Qu.: 3.465 3rd Qu.: 25.50 3rd Qu.:33.25
## Max. : 55.000 Max. : 178.00 Max. :44.00
##
## avg_roll_arm stddev_roll_arm var_roll_arm avg_pitch_arm
## Mode:logical Mode:logical Mode:logical Mode:logical
## NA's:20 NA's:20 NA's:20 NA's:20
##
##
##
##
## stddev_pitch_arm var_pitch_arm avg_yaw_arm stddev_yaw_arm
## Mode:logical Mode:logical Mode:logical Mode:logical
## NA's:20 NA's:20 NA's:20 NA's:20
##
##
##
##
## var_yaw_arm gyros_arm_x gyros_arm_y gyros_arm_z
## Mode:logical Min. :-3.710 Min. :-2.0900 Min. :-0.6900
## NA's:20 1st Qu.: -0.645 1st Qu.: -0.6350 1st Qu.: -0.1800
## Median : 0.020 Median : -0.0400 Median : -0.0250
## Mean : 0.077 Mean : -0.1595 Mean : 0.1205
## 3rd Qu.: 1.248 3rd Qu.: 0.2175 3rd Qu.: 0.5650
## 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    kurtosis_roll_arm kurtosis_picth_arm
## Min.      :-307.0    Min.      :-499.0    Mode:logical      Mode:logical
## 1st Qu.: 205.2    1st Qu.: 403.0    NA's:20            NA's:20
## Median : 291.0    Median : 476.5
## Mean      : 239.4    Mean      : 369.8
## 3rd Qu.: 358.8    3rd Qu.: 517.0
## Max.      : 474.0    Max.      : 633.0
##
## kurtosis_yaw_arm skewness_roll_arm skewness_pitch_arm skewness_yaw_arm
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20            NA's:20            NA's:20            NA's:20
##
##
##
##
## max_roll_arm    max_picth_arm    max_yaw_arm    min_roll_arm
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20            NA's:20            NA's:20            NA's:20
##
##
##
##
## min_pitch_arm    min_yaw_arm    amplitude_roll_arm amplitude_pitch_arm
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20            NA's:20            NA's:20            NA's:20
##
##
##
##
## amplitude_yaw_arm roll_dumbbell    pitch_dumbbell    yaw_dumbbell
## Mode:logical      Min.      :-111.118    Min.      :-54.97    Min.      :-103.3200
## NA's:20            1st Qu.: 7.494    1st Qu.: -51.89    1st Qu.: -75.2809
##                      Median : 50.403    Median : -40.81    Median : -8.2863
##                      Mean      : 33.760    Mean      : -19.47    Mean      : -0.9385
##                      3rd Qu.: 58.129    3rd Qu.: 16.12    3rd Qu.: 55.8335
##                      Max.      : 123.984    Max.      : 96.87    Max.      : 132.2337
##
## kurtosis_roll_dumbbell kurtosis_picth_dumbbell kurtosis_yaw_dumbbell
## Mode:logical      Mode:logical      Mode:logical
## NA's:20            NA's:20            NA's:20
##
##
##
##
## skewness_roll_dumbbell skewness_pitch_dumbbell skewness_yaw_dumbbell
## Mode:logical      Mode:logical      Mode:logical
## NA's:20            NA's:20            NA's:20
##
##

```

```

##
##
##
##
## max_roll_dumbbell max_pitch_dumbbell max_yaw_dumbbell min_roll_dumbbell
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20           NA's:20
##
##
##
##
## min_pitch_dumbbell min_yaw_dumbbell amplitude_roll_dumbbell
## Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20
##
##
##
##
## amplitude_pitch_dumbbell amplitude_yaw_dumbbell total_accel_dumbbell
## Mode:logical      Mode:logical      Min.      : 1.0
## NA's:20           NA's:20           1st Qu.: 7.0
##                                     Median :15.5
##                                     Mean   :17.2
##                                     3rd Qu.:29.0
##                                     Max.   :31.0
##
## var_accel_dumbbell avg_roll_dumbbell stddev_roll_dumbbell
## Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20
##
##
##
##
## var_roll_dumbbell avg_pitch_dumbbell stddev_pitch_dumbbell
## Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20
##
##
##
##
## var_pitch_dumbbell avg_yaw_dumbbell stddev_yaw_dumbbell var_yaw_dumbbell
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20           NA's:20
##
##
##
##
## gyros_dumbbell_x gyros_dumbbell_y gyros_dumbbell_z accel_dumbbell_x
## Min.      :-1.0300 Min.      :-1.1100 Min.      :-1.180 Min.      :-159.00

```

```

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

```

```

## amplitude_pitch_forearm amplitude_yaw_forearm total_accel_forearm
## Mode:logical          Mode:logical          Min.    :21.00
## NA's:20              NA's:20              1st Qu.:24.00
##                      Median :32.50
##                      Mean    :32.05
##                      3rd Qu.:36.75
##                      Max.    :47.00
##
## var_accel_forearm avg_roll_forearm stddev_roll_forearm var_roll_forearm
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20           NA's:20
##
##
##
##
## avg_pitch_forearm stddev_pitch_forearm var_pitch_forearm avg_yaw_forearm
## Mode:logical      Mode:logical      Mode:logical      Mode:logical
## NA's:20           NA's:20           NA's:20           NA's:20
##
##
##
##
## stddev_yaw_forearm var_yaw_forearm gyros_forearm_x  gyros_forearm_y
## Mode:logical      Mode:logical      Min.    :-1.0600  Min.    :-5.9700
## NA's:20           NA's:20           1st Qu.: -0.5850  1st Qu.: -1.2875
##                      Median : 0.0200  Median : 0.0350
##                      Mean    :-0.0200  Mean    :-0.0415
##                      3rd Qu.: 0.2925  3rd Qu.: 2.0475
##                      Max.    : 1.3800  Max.    : 4.2600
##
## gyros_forearm_z  accel_forearm_x  accel_forearm_y  accel_forearm_z
## Min.    :-1.2600  Min.    :-212.0  Min.    :-331.0  Min.    :-282.0
## 1st Qu.: -0.0975  1st Qu.: -114.8  1st Qu.: 8.5     1st Qu.: -199.0
## Median : 0.2300  Median : 86.0    Median : 138.0   Median : -148.5
## Mean    : 0.2610  Mean    : 38.8    Mean    : 125.3   Mean    : -93.7
## 3rd Qu.: 0.7625  3rd Qu.: 166.2   3rd Qu.: 268.0   3rd Qu.: -31.0
## Max.    : 1.8000  Max.    : 232.0   Max.    : 406.0   Max.    : 179.0
##
## magnet_forearm_x magnet_forearm_y magnet_forearm_z  problem_id
## Min.    :-714.0  Min.    :-787.0  Min.    :-32.0   Min.    : 1.00
## 1st Qu.: -427.2  1st Qu.: -328.8  1st Qu.: 275.2   1st Qu.: 5.75
## Median : -189.5  Median : 487.0   Median : 491.5   Median : 10.50
## Mean    : -159.2  Mean    : 191.8   Mean    : 460.2   Mean    : 10.50
## 3rd Qu.: 41.5    3rd Qu.: 720.8   3rd Qu.: 661.5   3rd Qu.: 15.25
## Max.    : 532.0  Max.    : 800.0   Max.    : 884.0   Max.    : 20.00
##

```

These steps show each row of the data is one sample of weight-lifting activity. There were 19622 samples in training dataset, and 20 samples in testing dataset. The goal of this assignment was to use accelerometer information only to predict classe. Some of the accelerometer variables have missing values.

Pre-process the data

1. Use accelerometer data only

```
names(data0)
```

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



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

```
index1<-grep("accel", names(data0))
data1<-data0[,c(index1, 160)]
coursera1<-coursera0[,c(index1, 160)]
summary(data1)
```

```
## total_accel_belt var_total_accel_belt accel_belt_x accel_belt_y
## Min. : 0.00 Min. : 0.000 Min. : -120.000 Min. : -69.00
## 1st Qu.: 3.00 1st Qu.: 0.100 1st Qu.: -21.000 1st Qu.: 3.00
## Median :17.00 Median : 0.200 Median : -15.000 Median : 35.00
## Mean :11.31 Mean : 0.926 Mean : -5.595 Mean : 30.15
## 3rd Qu.:18.00 3rd Qu.: 0.300 3rd Qu.: -5.000 3rd Qu.: 61.00
## Max. :29.00 Max. :16.500 Max. : 85.000 Max. :164.00
## NA's :19216
## accel_belt_z total_accel_arm var_accel_arm accel_arm_x
## Min. : -275.00 Min. : 1.00 Min. : 0.00 Min. : -404.00
## 1st Qu.: -162.00 1st Qu.:17.00 1st Qu.: 9.03 1st Qu.: -242.00
## Median : -152.00 Median :27.00 Median : 40.61 Median : -44.00
## Mean : -72.59 Mean :25.51 Mean : 53.23 Mean : -60.24
## 3rd Qu.: 27.00 3rd Qu.:33.00 3rd Qu.: 75.62 3rd Qu.: 84.00
## Max. : 105.00 Max. :66.00 Max. :331.70 Max. : 437.00
## NA's :19216
## accel_arm_y accel_arm_z total_accel_dumbbell
## Min. : -318.0 Min. : -636.00 Min. : 0.00
```

```
## 1st Qu.: -54.0    1st Qu.: -143.00    1st Qu.: 4.00
## Median : 14.0    Median : -47.00    Median :10.00
## Mean : 32.6    Mean : -71.25    Mean :13.72
## 3rd Qu.: 139.0    3rd Qu.: 23.00    3rd Qu.:19.00
## Max. : 308.0    Max. : 292.00    Max. :58.00
##
## var_accel_dumbbell accel_dumbbell_x accel_dumbbell_y accel_dumbbell_z
## Min. : 0.000    Min. : -419.00    Min. : -189.00    Min. : -334.00
## 1st Qu.: 0.378    1st Qu.: -50.00    1st Qu.: -8.00    1st Qu.: -142.00
## Median : 1.000    Median : -8.00    Median : 41.50    Median : -1.00
## Mean : 4.388    Mean : -28.62    Mean : 52.63    Mean : -38.32
## 3rd Qu.: 3.434    3rd Qu.: 11.00    3rd Qu.: 111.00    3rd Qu.: 38.00
## Max. :230.428    Max. : 235.00    Max. : 315.00    Max. : 318.00
## NA's :19216
## total_accel_forearm var_accel_forearm accel_forearm_x accel_forearm_y
## Min. : 0.00    Min. : 0.000    Min. : -498.00    Min. : -632.0
## 1st Qu.: 29.00    1st Qu.: 6.759    1st Qu.: -178.00    1st Qu.: 57.0
## Median : 36.00    Median : 21.165    Median : -57.00    Median : 201.0
## Mean : 34.72    Mean : 33.502    Mean : -61.65    Mean : 163.7
## 3rd Qu.: 41.00    3rd Qu.: 51.240    3rd Qu.: 76.00    3rd Qu.: 312.0
## Max. :108.00    Max. :172.606    Max. : 477.00    Max. : 923.0
## NA's :19216
## accel_forearm_z classe
## Min. : -446.00    A:5580
## 1st Qu.: -182.00    B:3797
## Median : -39.00    C:3422
## Mean : -55.29    D:3216
## 3rd Qu.: 26.00    E:3607
## Max. : 291.00
##
```

`summary(coursera1)`

```
## total_accel_belt var_total_accel_belt accel_belt_x accel_belt_y
## Min. : 2.00    Mode:logical    Min. : -48.00    Min. : -16.00
## 1st Qu.: 3.00    NA's:20          1st Qu.: -19.00    1st Qu.: 2.00
## Median : 4.00          Median : -13.00    Median : 4.50
## Mean : 7.55          Mean : -13.50    Mean : 18.35
## 3rd Qu.: 8.00          3rd Qu.: -8.75    3rd Qu.: 25.50
## Max. :21.00          Max. : 46.00    Max. : 72.00
## accel_belt_z total_accel_arm var_accel_arm accel_arm_x
## Min. : -187.00    Min. : 3.00    Mode:logical    Min. : -341.0
## 1st Qu.: -24.00    1st Qu.:20.25    NA's:20          1st Qu.: -277.0
## Median : 27.00    Median :29.50          Median : -194.5
## Mean : -17.60    Mean :26.40          Mean : -134.6
## 3rd Qu.: 38.25    3rd Qu.:33.25          3rd Qu.: 5.5
## Max. : 49.00    Max. :44.00          Max. : 106.0
## accel_arm_y accel_arm_z total_accel_dumbbell
## Min. : -65.00    Min. : -404.00    Min. : 1.0
## 1st Qu.: 52.25    1st Qu.: -128.50    1st Qu.: 7.0
## Median :112.00    Median : -83.50    Median :15.5
## Mean :103.10    Mean : -87.85    Mean :17.2
## 3rd Qu.:168.25    3rd Qu.: -27.25    3rd Qu.:29.0
## Max. :245.00    Max. : 93.00    Max. :31.0
## var_accel_dumbbell accel_dumbbell_x accel_dumbbell_y accel_dumbbell_z
```

```
## Mode:logical      Min.    :-159.00  Min.    :-30.00  Min.    :-221.0
## NA's:20           1st Qu.: -140.25  1st Qu.:  5.75  1st Qu.: -192.2
##                   Median :  -19.00  Median : 71.50  Median :   -3.0
##                   Mean    : -47.60  Mean    : 70.55  Mean    : -60.0
##                   3rd Qu.:  15.75  3rd Qu.:151.25  3rd Qu.:  76.5
##                   Max.    : 185.00  Max.    :166.00  Max.    : 100.0
## total_accel_forearm var_accel_forearm accel_forearm_x accel_forearm_y
## Min.    :21.00      Mode:logical      Min.    :-212.0  Min.    :-331.0
## 1st Qu.:24.00      NA's:20           1st Qu.: -114.8  1st Qu.:   8.5
## Median :32.50                      Median :   86.0  Median : 138.0
## Mean    :32.05                      Mean    :   38.8  Mean    : 125.3
## 3rd Qu.:36.75                      3rd Qu.: 166.2  3rd Qu.: 268.0
## Max.    :47.00                      Max.    : 232.0  Max.    : 406.0
## accel_forearm_z    problem_id
## Min.    :-282.0    Min.    : 1.00
## 1st Qu.: -199.0    1st Qu.: 5.75
## Median : -148.5    Median :10.50
## Mean    : -93.7    Mean    :10.50
## 3rd Qu.: -31.0     3rd Qu.:15.25
## Max.    : 179.0    Max.    :20.00
```

2. Handle missing data:

According to the previous step, in both data0 and coursera0, there were 20 feature. 4 out of these 20 features have missing (NA).

We may use K-nearest neighbor to impute missing data (the results will be standardized). However, because only 406 out of 19622 records have non-missing data for these four features in traininga, and these 4 features have no non-missing data at all in the testinga data. Therefore, simply deleting these four features is the best choice.

```
data2<-data1[,-c(2,7,12,17)]
coursera2<-coursera1[,-c(2,7,12,17)]
```

3. Data partition to training and testing

```
library("caret")

## Loading required package: lattice
## Loading required package: ggplot2
inTrain = createDataPartition(data2$class, p = 3/4)[[1]]
training = data2[ inTrain,]
testing = data2[-inTrain,]
```

Build model

1. Choice of models:

With labels, this project need supervised learning. The label in this project is five categories of activities (A, B, C, D, and D). Therefore, this project need classification rather than regression algorithms. Random forest might perform well for this data, with relatively good accuracy (low bias), low variance, and appreciable interpretability.

2. Cross-validation:

Random forest is an ensembling learning method and resampling could be used to adjust tuning parameters. Cross-validation is used here to find the best mtry parameter in random forest.

```

set.seed(33833)
mod1<-train(classe ~.,method="rf", data=training, trControl = trainControl(method="cv"),number=3)

pred1<-predict(mod1, testing)
confusionMatrix(pred1, testing$classe)

```

```

## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##           A 1336   40   16   16    3
##           B    9  871   17    4    9
##           C   22   24  812   32   11
##           D   27    8   10  747    5
##           E    1    6    0    5  873
##
## Overall Statistics
##
##           Accuracy : 0.946
##           95% CI : (0.9393, 0.9521)
##           No Information Rate : 0.2845
##           P-Value [Acc > NIR] : < 2.2e-16
##
##           Kappa : 0.9316
##
## Mcnemar's Test P-Value : 2.64e-07
##
## Statistics by Class:
##
##           Class: A Class: B Class: C Class: D Class: E
## Sensitivity      0.9577   0.9178   0.9497   0.9291   0.9689
## Specificity      0.9786   0.9901   0.9780   0.9878   0.9970
## Pos Pred Value   0.9468   0.9571   0.9012   0.9373   0.9864
## Neg Pred Value   0.9831   0.9805   0.9893   0.9861   0.9930
## Prevalence       0.2845   0.1935   0.1743   0.1639   0.1837
## Detection Rate   0.2724   0.1776   0.1656   0.1523   0.1780
## Detection Prevalence 0.2877   0.1856   0.1837   0.1625   0.1805
## Balanced Accuracy 0.9682   0.9540   0.9639   0.9585   0.9830

```

Using this seed, we got a final prediction algorithm with an accuracy of 94.15%.

Apply to coursera exam

```

pred1<-predict(mod1, coursera2)
results<-data.frame(id=coursera0$problem_id, pred1)
results

```

```

##   id pred1
## 1  1     B
## 2  2     A
## 3  3     C
## 4  4     A
## 5  5     A

```

##	6	6	E
##	7	7	D
##	8	8	B
##	9	9	A
##	10	10	A
##	11	11	B
##	12	12	C
##	13	13	B
##	14	14	A
##	15	15	E
##	16	16	E
##	17	17	A
##	18	18	B
##	19	19	C
##	20	20	B

Reference

Velloso, E.; Bulling, A.; Gellersen, H.; Ugulino, W.; Fuks, H. Qualitative Activity Recognition of Weight Lifting Exercises. Proceedings of 4th International Conference in Cooperation with SIGCHI (Augmented Human '13) . Stuttgart, Germany: ACM SIGCHI, 2013.