pml

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#question Analysis of Tooth growth data set.

#Load the data

```
library(caret)
```

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

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

```
library(Hmisc)
```

```
## Warning: package 'Hmisc' was built under R version 3.6.3
```

```
## Loading required package: survival
```

```
##
## Attaching package: 'survival'
```

```
## The following object is masked from 'package:caret':
##
##     cluster
```

```
## Loading required package: Formula
```

```
##
## Attaching package: 'Hmisc'
```

```
## The following objects are masked from 'package:base':
##
##     format.pval, units
```

```
library(corrplot)
```

```
## Warning: package 'corrplot' was built under R version 3.6.3
```

```
## corrplot 0.84 loaded
```

```
library(e1071)
```

```
## Warning: package 'e1071' was built under R version 3.6.3
```

```
##
## Attaching package: 'e1071'
```

```
## The following object is masked from 'package:Hmisc':
##
##     impute
```

```
library(randomForest)
```

```
## Warning: package 'randomForest' was built under R version 3.6.3
```

```
## 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
```

```
set.seed(3566)
download.file("https://d396qusza40orc.cloudfront.net/predmachlearn/pml-training.csv",
              destfile = "./training.csv",
              method = "curl")

download.file("https://d396qusza40orc.cloudfront.net/predmachlearn/pml-testing.csv",
              destfile = "./testing.csv",
              method = "curl")
```

```
train1 = read.csv("training.csv")
test1 = read.csv("testing.csv")
```

Next step is to find any missing values and clean the data.

```
set.seed(3566)
summary(train1)
```

```
##        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 skewness_roll_belt.1
##            :19216            :19216             :19216            :19216
##  #DIV/0!  :   32     #DIV/0!:  406     #DIV/0!  :    9    #DIV/0!  :   32
##  47.000000:    4                       0.000000 :    4    0.000000 :    4
##  -0.150950:    3                       0.422463 :    2    -2.156553:    3
##  -0.684748:    3                       -0.003095:    1    -3.072669:    3
##  -1.750749:    3                       -0.010002:    1    -6.324555:    3
##  (Other)  :  361                       (Other)  :  389    (Other)  :  361
##  skewness_yaw_belt max_roll_belt     max_picth_belt   max_yaw_belt
##         :19216     Min.   :-94.300   Min.   : 3.00          :19216
##  #DIV/0!:  406     1st Qu.:-88.000   1st Qu.: 5.00   -1.1   :   30
##                    Median : -5.100   Median :18.00   -1.4   :   29
##                    Mean   : -6.667   Mean   :12.92   -1.2   :   26
##                    3rd Qu.: 18.500   3rd Qu.:19.00   -0.9   :   24
##                    Max.   :180.000   Max.   :30.00   -1.3   :   22
##                    NA's   :19216     NA's   :19216   (Other):  275
##  min_roll_belt     min_pitch_belt   min_yaw_belt   amplitude_roll_belt
##  Min.   :-180.00   Min.   : 0.00          :19216   Min.   :  0.000
##  1st Qu.: -88.40   1st Qu.: 3.00   -1.1   :   30   1st Qu.:  0.300
##  Median :  -7.85   Median :16.00   -1.4   :   29   Median :  1.000
##  Mean   : -10.44   Mean   :10.76   -1.2   :   26   Mean   :  3.769
##  3rd Qu.:   9.05   3rd Qu.:17.00   -0.9   :   24   3rd Qu.:  2.083
##  Max.   : 173.00   Max.   :23.00   -1.3   :   22   Max.   :360.000
##  NA's   :19216     NA's   :19216   (Other):  275   NA's   :19216
##  amplitude_pitch_belt amplitude_yaw_belt var_total_accel_belt avg_roll_belt
##  Min.   : 0.000              :19216      Min.   : 0.000       Min.   :-27.40
##  1st Qu.: 1.000       #DIV/0!:   10      1st Qu.: 0.100       1st Qu.:  1.10
##  Median : 1.000       0.00   :   12      Median : 0.200       Median :116.35
##  Mean   : 2.167       0.0000 :  384      Mean   : 0.926       Mean   : 68.06
##  3rd Qu.: 2.000                          3rd Qu.: 0.300       3rd Qu.:123.38
##  Max.   :12.000                          Max.   :16.500       Max.   :157.40
##  NA's   :19216                           NA's   :19216        NA's   :19216
##  stddev_roll_belt var_roll_belt     avg_pitch_belt    stddev_pitch_belt
##  Min.   : 0.000   Min.   :  0.000   Min.   :-51.400   Min.   :0.000
##  1st Qu.: 0.200   1st Qu.:  0.000   1st Qu.:  2.025   1st Qu.:0.200
##  Median : 0.400   Median :  0.100   Median :  5.200   Median :0.400
```

```
##  Mean   : 1.337   Mean   :  7.699   Mean   :  0.520   Mean   :0.603
##  3rd Qu.: 0.700   3rd Qu.:  0.500   3rd Qu.: 15.775   3rd Qu.:0.700
##  Max.   :14.200   Max.   :200.700   Max.   : 59.700   Max.   :4.000
##  NA's   :19216    NA's   :19216     NA's   :19216     NA's   :19216
##  var_pitch_belt    avg_yaw_belt      stddev_yaw_belt    var_yaw_belt
##  Min.   : 0.000   Min.   :-138.300   Min.   :  0.000   Min.   :    0.000
##  1st Qu.: 0.000   1st Qu.: -88.175   1st Qu.:  0.100   1st Qu.:    0.010
##  Median : 0.100   Median :  -6.550   Median :  0.300   Median :    0.090
##  Mean   : 0.766   Mean   :  -8.831   Mean   :  1.341   Mean   :  107.487
##  3rd Qu.: 0.500   3rd Qu.:  14.125   3rd Qu.:  0.700   3rd Qu.:    0.475
##  Max.   :16.200   Max.   : 173.500   Max.   :176.600   Max.   :31183.240
##  NA's   :19216    NA's   :19216      NA's   :19216     NA's   :19216
##   gyros_belt_x        gyros_belt_y       gyros_belt_z      accel_belt_x
##  Min.   :-1.040000   Min.   :-0.64000   Min.   :-1.4600   Min.   :-120.000
##  1st Qu.:-0.030000   1st Qu.: 0.00000   1st Qu.:-0.2000   1st Qu.: -21.000
##  Median : 0.030000   Median : 0.02000   Median :-0.1000   Median : -15.000
##  Mean   :-0.005592   Mean   : 0.03959   Mean   :-0.1305   Mean   :  -5.595
##  3rd Qu.: 0.110000   3rd Qu.: 0.11000   3rd Qu.:-0.0200   3rd Qu.:  -5.000
##  Max.   : 2.220000   Max.   : 0.64000   Max.   : 1.6200   Max.   :  85.000
##
##   accel_belt_y     accel_belt_z     magnet_belt_x   magnet_belt_y
##  Min.   :-69.00   Min.   :-275.00   Min.   :-52.0   Min.   :354.0
##  1st Qu.:  3.00   1st Qu.:-162.00   1st Qu.:  9.0   1st Qu.:581.0
##  Median : 35.00   Median :-152.00   Median : 35.0   Median :601.0
##  Mean   : 30.15   Mean   : -72.59   Mean   : 55.6   Mean   :593.7
##  3rd Qu.: 61.00   3rd Qu.:  27.00   3rd Qu.: 59.0   3rd Qu.:610.0
##  Max.   :164.00   Max.   : 105.00   Max.   :485.0   Max.   :673.0
##
##  magnet_belt_z       roll_arm         pitch_arm          yaw_arm
##  Min.   :-623.0   Min.   :-180.00   Min.   :-88.800   Min.   :-180.0000
##  1st Qu.:-375.0   1st Qu.: -31.77   1st Qu.:-25.900   1st Qu.: -43.1000
##  Median :-320.0   Median :   0.00   Median :  0.000   Median :   0.0000
##  Mean   :-345.5   Mean   :  17.83   Mean   : -4.612   Mean   :  -0.6188
##  3rd Qu.:-306.0   3rd Qu.:  77.30   3rd Qu.: 11.200   3rd Qu.:  45.8750
##  Max.   : 293.0   Max.   : 180.00   Max.   : 88.500   Max.   : 180.0000
##
##  total_accel_arm var_accel_arm     avg_roll_arm     stddev_roll_arm
##  Min.   : 1.00   Min.   :  0.00   Min.   :-166.67   Min.   :  0.000
##  1st Qu.:17.00   1st Qu.:  9.03   1st Qu.: -38.37   1st Qu.:  1.376
##  Median :27.00   Median : 40.61   Median :   0.00   Median :  5.702
##  Mean   :25.51   Mean   : 53.23   Mean   :  12.68   Mean   : 11.201
##  3rd Qu.:33.00   3rd Qu.: 75.62   3rd Qu.:  76.33   3rd Qu.: 14.921
##  Max.   :66.00   Max.   :331.70   Max.   : 163.33   Max.   :161.964
##                  NA's   :19216    NA's   :19216     NA's   :19216
##   var_roll_arm       avg_pitch_arm     stddev_pitch_arm var_pitch_arm
##  Min.   :    0.000   Min.   :-81.773   Min.   : 0.000   Min.   :   0.000
##  1st Qu.:    1.898   1st Qu.:-22.770   1st Qu.: 1.642   1st Qu.:   2.697
##  Median :   32.517   Median :  0.000   Median : 8.133   Median :  66.146
##  Mean   :  417.264   Mean   : -4.901   Mean   :10.383   Mean   : 195.864
##  3rd Qu.:  222.647   3rd Qu.:  8.277   3rd Qu.:16.327   3rd Qu.: 266.576
##  Max.   :26232.208   Max.   : 75.659   Max.   :43.412   Max.   :1884.565
##  NA's   :19216       NA's   :19216     NA's   :19216    NA's   :19216
##   avg_yaw_arm       stddev_yaw_arm     var_yaw_arm         gyros_arm_x
##  Min.   :-173.440   Min.   :  0.000   Min.   :    0.000   Min.   :-6.37000
```

```
##  1st Qu.: -29.198   1st Qu.:  2.577   1st Qu.:    6.642   1st Qu.:-1.33000
##  Median :   0.000   Median : 16.682   Median :  278.309   Median : 0.08000
##  Mean   :   2.359   Mean   : 22.270   Mean   : 1055.933   Mean   : 0.04277
##  3rd Qu.:  38.185   3rd Qu.: 35.984   3rd Qu.: 1294.850   3rd Qu.: 1.57000
##  Max.   : 152.000   Max.   :177.044   Max.   :31344.568   Max.   : 4.87000
##  NA's   :19216      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_picth_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_picth_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 roll_dumbbell
##  Min.   :  0.000    Min.   :  0.000     Min.   : 0.00     Min.   :-153.71
##  1st Qu.:  5.425    1st Qu.:  9.925     1st Qu.:13.00     1st Qu.: -18.49
##  Median : 28.450    Median : 54.900     Median :22.00     Median :  48.17
##  Mean   : 32.452    Mean   : 69.677     Mean   :20.79     Mean   :  23.84
##  3rd Qu.: 50.960    3rd Qu.:115.175     3rd Qu.:28.75     3rd Qu.:  67.61
##  Max.   :119.500    Max.   :360.000     Max.   :52.00     Max.   : 153.55
##  NA's   :19216      NA's   :19216       NA's   :19216
```

```
##  pitch_dumbbell     yaw_dumbbell      kurtosis_roll_dumbbell
##  Min.   :-149.59   Min.   :-150.871          :19216
##  1st Qu.: -40.89   1st Qu.: -77.644   #DIV/0!:    5
##  Median : -20.96   Median :  -3.324   -0.2583:    2
##  Mean   : -10.78   Mean   :   1.674   -0.3705:    2
##  3rd Qu.:  17.50   3rd Qu.:  79.643   -0.5855:    2
##  Max.   : 149.40   Max.   : 154.952   -2.0851:    2
##                                       (Other):  393
##  kurtosis_picth_dumbbell kurtosis_yaw_dumbbell skewness_roll_dumbbell
##         :19216                   :19216                :19216
##  -0.5464:    2           #DIV/0!:  406         #DIV/0!:    4
##  -0.9334:    2                                 -0.9324:    2
##  -2.0833:    2                                 0.1110 :    2
##  -2.0851:    2                                 1.0312 :    2
##  -2.0889:    2                                 -0.0082:    1
##  (Other):  396                                 (Other):  395
##  skewness_pitch_dumbbell skewness_yaw_dumbbell max_roll_dumbbell
##         :19216                   :19216         Min.   :-70.10
##  -0.2328:    2           #DIV/0!:  406         1st Qu.:-27.15
##  -0.3521:    2                                 Median : 14.85
##  -0.7036:    2                                 Mean   : 13.76
##  0.1090 :    2                                 3rd Qu.: 50.58
##  1.0326 :    2                                 Max.   :137.00
##  (Other):  396                                 NA's   :19216
##  max_picth_dumbbell max_yaw_dumbbell min_roll_dumbbell min_pitch_dumbbell
##  Min.   :-112.90           :19216    Min.   :-149.60   Min.   :-147.00
##  1st Qu.: -66.70    -0.6   :   20    1st Qu.: -59.67   1st Qu.: -91.80
##  Median :  40.05    0.2    :   19    Median : -43.55   Median : -66.15
##  Mean   :  32.75    -0.8   :   18    Mean   : -41.24   Mean   : -33.18
##  3rd Qu.: 133.22    -0.3   :   16    3rd Qu.: -25.20   3rd Qu.:  21.20
##  Max.   : 155.00    -0.2   :   15    Max.   :  73.20   Max.   : 120.90
##  NA's   :19216      (Other):  318    NA's   :19216     NA's   :19216
##  min_yaw_dumbbell amplitude_roll_dumbbell amplitude_pitch_dumbbell
##         :19216    Min.   :  0.00          Min.   :  0.00
##  -0.6   :   20    1st Qu.: 14.97          1st Qu.: 17.06
##  0.2    :   19    Median : 35.05          Median : 41.73
##  -0.8   :   18    Mean   : 55.00          Mean   : 65.93
##  -0.3   :   16    3rd Qu.: 81.04          3rd Qu.: 99.55
##  -0.2   :   15    Max.   :256.48          Max.   :273.59
##  (Other):  318    NA's   :19216           NA's   :19216
##  amplitude_yaw_dumbbell total_accel_dumbbell var_accel_dumbbell
##         :19216          Min.   : 0.00        Min.   :  0.000
##  #DIV/0!:    5          1st Qu.: 4.00        1st Qu.:  0.378
##  0.00   :  401          Median :10.00        Median :  1.000
##                         Mean   :13.72        Mean   :  4.388
##                         3rd Qu.:19.00        3rd Qu.:  3.434
##                         Max.   :58.00        Max.   :230.428
##                                              NA's   :19216
##  avg_roll_dumbbell stddev_roll_dumbbell var_roll_dumbbell  avg_pitch_dumbbell
##  Min.   :-128.96   Min.   :  0.000      Min.   :    0.00   Min.   :-70.73
##  1st Qu.: -12.33   1st Qu.:  4.639      1st Qu.:   21.52   1st Qu.:-42.00
##  Median :  48.23   Median : 12.204      Median :  148.95   Median :-19.91
##  Mean   :  23.86   Mean   : 20.761      Mean   : 1020.27   Mean   :-12.33
##  3rd Qu.:  64.37   3rd Qu.: 26.356      3rd Qu.:  694.65   3rd Qu.: 13.21
```

```
##  Max.   : 125.99   Max.   :123.778      Max.   :15321.01   Max.   : 94.28
##  NA's   :19216     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    gyros_dumbbell_y
##  Min.   :  0.000     Min.   :    0.00   Min.   :-204.0000   Min.   :-2.10000
##  1st Qu.:  3.885     1st Qu.:   15.09   1st Qu.:  -0.0300   1st Qu.:-0.14000
##  Median : 10.264     Median :  105.35   Median :   0.1300   Median : 0.03000
##  Mean   : 16.647     Mean   :  589.84   Mean   :   0.1611   Mean   : 0.04606
##  3rd Qu.: 24.674     3rd Qu.:  608.79   3rd Qu.:   0.3500   3rd Qu.: 0.21000
##  Max.   :107.088     Max.   :11467.91   Max.   :   2.2200   Max.   :52.00000
##  NA's   :19216       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_picth_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 max_picth_forearm
##         :19216                  :19216        Min.   :-66.60   Min.   :-151.00
##  #DIV/0!:   85          #DIV/0!:  406        1st Qu.:  0.00   1st Qu.:   0.00
##  0.0000 :    4                               Median : 26.80   Median : 113.00
```

```
##  -0.6992:    2                                  Mean   : 24.49   Mean   :  81.49
##  -0.0113:    1                                  3rd Qu.: 45.95   3rd Qu.: 174.75
##  -0.0131:    1                                  Max.   : 89.80   Max.   : 180.00
##  (Other):  313                                  NA's   :19216    NA's   :19216
##  max_yaw_forearm min_roll_forearm  min_pitch_forearm min_yaw_forearm
##        :19216   Min.   :-72.500   Min.   :-180.00          :19216
##  #DIV/0!:   84   1st Qu.: -6.075   1st Qu.:-175.00   #DIV/0!:   84
##  -1.2   :   32   Median :  0.000   Median : -61.00   -1.2   :   32
##  -1.3   :   31   Mean   : -0.167   Mean   : -57.57   -1.3   :   31
##  -1.4   :   24   3rd Qu.: 12.075   3rd Qu.:   0.00   -1.4   :   24
##  -1.5   :   24   Max.   : 62.100   Max.   : 167.00   -1.5   :   24
##  (Other):  211   NA's   :19216     NA's   :19216     (Other):  211
##  amplitude_roll_forearm amplitude_pitch_forearm amplitude_yaw_forearm
##  Min.   :  0.000        Min.   :  0.0                   :19216
##  1st Qu.:  1.125        1st Qu.:  2.0           #DIV/0!:   84
##  Median : 17.770        Median : 83.7           0.00   :  322
##  Mean   : 24.653        Mean   :139.1
##  3rd Qu.: 39.875        3rd Qu.:350.0
##  Max.   :126.000        Max.   :360.0
##  NA's   :19216          NA's   :19216
##  total_accel_forearm var_accel_forearm avg_roll_forearm   stddev_roll_forearm
##  Min.   :  0.00      Min.   :  0.000   Min.   :-177.234   Min.   :  0.000
##  1st Qu.: 29.00      1st Qu.:  6.759   1st Qu.:  -0.909   1st Qu.:  0.428
##  Median : 36.00      Median : 21.165   Median :  11.172   Median :  8.030
##  Mean   : 34.72      Mean   : 33.502   Mean   :  33.165   Mean   : 41.986
##  3rd Qu.: 41.00      3rd Qu.: 51.240   3rd Qu.: 107.132   3rd Qu.: 85.373
##  Max.   :108.00      Max.   :172.606   Max.   : 177.256   Max.   :179.171
##                      NA's   :19216     NA's   :19216      NA's   :19216
##  var_roll_forearm   avg_pitch_forearm stddev_pitch_forearm var_pitch_forearm
##  Min.   :    0.00   Min.   :-68.17    Min.   : 0.000       Min.   :   0.000
##  1st Qu.:    0.18   1st Qu.:  0.00    1st Qu.: 0.336       1st Qu.:   0.113
##  Median :   64.48   Median : 12.02    Median : 5.516       Median :  30.425
##  Mean   : 5274.10   Mean   : 11.79    Mean   : 7.977       Mean   : 139.593
##  3rd Qu.: 7289.08   3rd Qu.: 28.48    3rd Qu.:12.866       3rd Qu.: 165.532
##  Max.   :32102.24   Max.   : 72.09    Max.   :47.745       Max.   :2279.617
##  NA's   :19216      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 classe
##  Min.   :-446.00   Min.   :-1280.0   Min.   :-896.0   Min.   :-973.0   A:5580
```

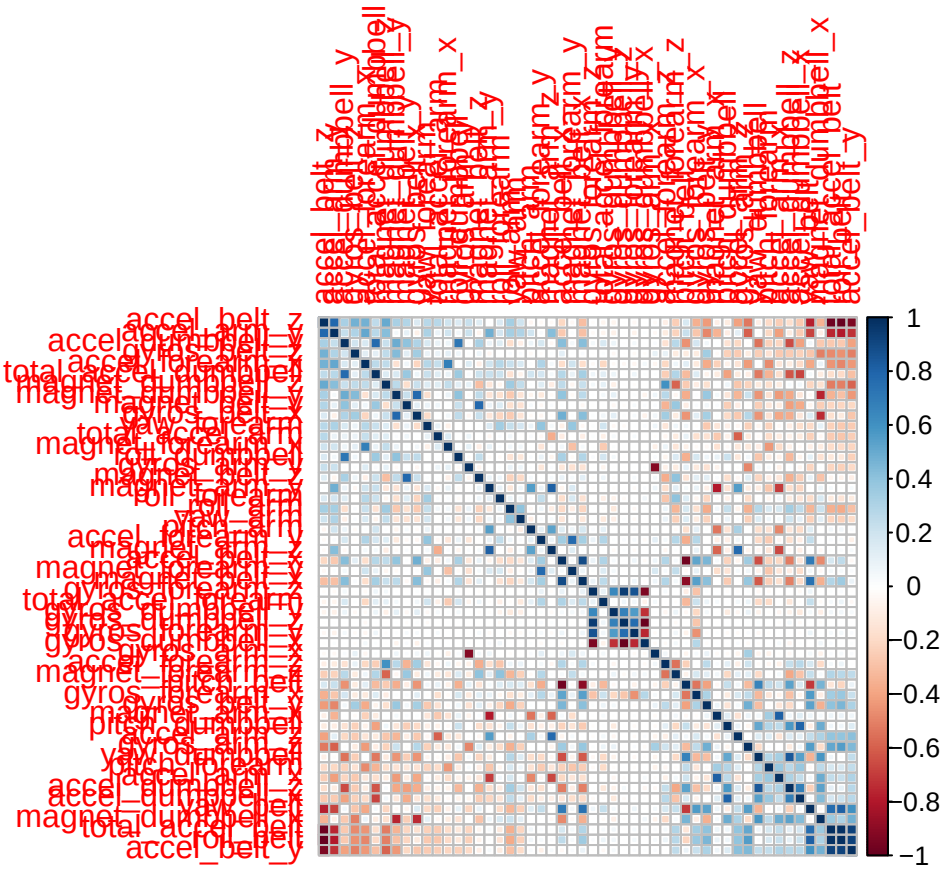
```
##  1st Qu.:-182.00   1st Qu.: -616.0   1st Qu.:   2.0   1st Qu.: 191.0   B:3797
##  Median : -39.00   Median : -378.0   Median : 591.0   Median : 511.0   C:3422
##  Mean   : -55.29   Mean   : -312.6   Mean   : 380.1   Mean   : 393.6   D:3216
##  3rd Qu.:  26.00   3rd Qu.:  -73.0   3rd Qu.: 737.0   3rd Qu.: 653.0   E:3607
##  Max.   : 291.00   Max.   :  672.0   Max.   :1480.0   Max.   :1090.0
##
```

```
set.seed(3566)
train = read.csv("training.csv", na.strings=c("#DIV/0!"))
train2 <- nearZeroVar(train)
train<-train[ , -train2]
variables <- colnames(train[colSums(is.na(train)) == 0])
d<- train[variables]
wd <- d[ , -(1:6)]
dim(wd)
```

```
## [1] 19622    53
```

#Splitting the dataset We now proceed to splitting our dataset into testing and training. Testing=0.75% and training=0.25% We also find correlation between attributes.

```
set.seed(3566)
Train3 <- createDataPartition(y=wd$classe, p=0.75, list=FALSE )
Trainingdata_sub <- wd[Train3,]
Testingdata_sub <- wd[-Train3,]
Q <- cor(Trainingdata_sub[ , -53])
corrplot(Q, order = "FPC", method = "square")
```



We observe the correlation between all the attributes of the dataset to find hidden patterns.

#Finding hidden patterns

We need to plot the confusion matrix to find the true positives, false positives, true negatives and the false negatives.

1. SVM:

```
set.seed(3566)
SVM1 <- svm(classe ~ ., data = Trainingdata_sub)
SVMPredict <- predict(SVM1, newdata = Testingdata_sub)
confusionMatrix(SVMPredict, Testingdata_sub$classe)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1388   75    1    2    0
##          B    2  844   36    0    9
##          C    5   27  805   64   25
##          D    0    0   13  734   24
##          E    0    3    0    4  843
##
## Overall Statistics
##
```

```
##                Accuracy : 0.9409
##                  95% CI : (0.9339, 0.9473)
##     No Information Rate : 0.2845
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.9251
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.9950   0.8894   0.9415   0.9129   0.9356
## Specificity            0.9778   0.9881   0.9701   0.9910   0.9983
## Pos Pred Value         0.9468   0.9473   0.8693   0.9520   0.9918
## Neg Pred Value         0.9980   0.9738   0.9874   0.9831   0.9857
## Prevalence             0.2845   0.1935   0.1743   0.1639   0.1837
## Detection Rate         0.2830   0.1721   0.1642   0.1497   0.1719
## Detection Prevalence   0.2989   0.1817   0.1888   0.1572   0.1733
## Balanced Accuracy      0.9864   0.9387   0.9558   0.9520   0.9669
```

The svm aka support vector machine model gave the accuracy 94.09%. This is a good model.