Personal Activity Data Analysis

Anish Joy

21 October 2017

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 dumbell 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

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.

Objective

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.

Data Import and Exploration

- Import the datasets

- Split the training datasets into training and validation datasets

```
inTrain = createDataPartition(data_main$classe, p = .7,list=F)
training<-data_main[inTrain,]
validation<-data_main[-inTrain,]
```

- Now perform exploratory analysis on the data to understand the underlying variables. The results are in Appendix. You can see that the first 7 variables are identifier variables and there are quite a lot of missing values which should be treated

Data Preparation

- Remove variables 1-7 from the data

- Remove variables which have missing values >=90% from the data. The 90% mark is quite subjective and this can be altered if required.

- Remove variables with near zero variance from the data
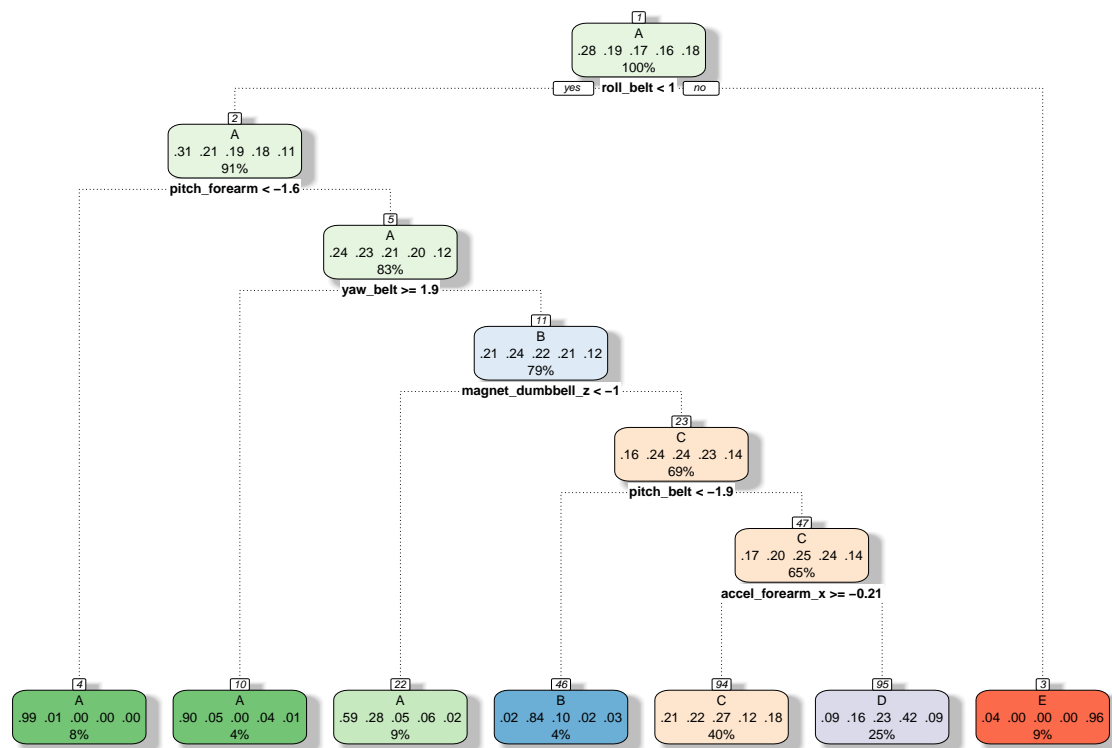
- Impute the missing values by using KNN

Modelling

- First of all create a training control to give the number of cross validation to be done on the modelling sets.

```
#Create Cross Validation Control
train_control<- trainControl(method="cv", number=5)
```

- we will be creating models based on Trees, Random Forest, Gradient Boosting Method and LDA. At first let us create a model using Decision Trees

```
#Create model using CART
modFitTree<- train(classe~.,data=training3,method="rpart")
fancyRpartPlot(modFitTree$finalMod,sub="Decision Tree on Training Data")
```


Decision Tree on Training Data

The Tree is able to create a simple relationship between the predictor and independent variables. This is a major advantage of Trees. The important variables shown in the tree are *roll_belt*, *pitch_forearm*, *magnet_dumbbell_y* and *roll_forearm*.

- Next we model using the Random Forest, then GBM and then LDA

```
#Create model using Random Forest
modFitRF<-train(classe~.,data=training3,method="rf")
```

```
## randomForest 4.6-12
```

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

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

## The following object is masked from 'package:rattle':
##
##      importance

## The following object is masked from 'package:ggplot2':
##
##      margin
```
```r
#Create model using GBM
modFitGBM<-train(classe~.,data=training3,method="gbm")
```
```
## Loading required package: survival

##
## Attaching package: 'survival'

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

## Loading required package: splines

## Loading required package: parallel

## Loaded gbm 2.1.3
```
```r
#Create model using LDA
modFitLDA<-train(classe~.,data=training3,method="lda")
```

Validation

- Once the modelling is done create confusion matrices on the validation datasets to evaluate the models

Print the Accuracy results

```
##   Model   Accuracy
## 1  CART 0.5024639
## 2   GBM 0.9624469
## 3    RF 0.9916737
## 4   LDA 0.5024639
```

- Random Forests have the best accuracy,hence, use the Random Forest to score and predict the testing dataset

```r
#Random Forest has the best accuracy
pred_fin_RF_test<-predict(modFitRF,newdata=testing2)
```

Appendix

- Summary of the Training Data

```
#Exploratory Analysis on the data
summary(data_main)
```

```
##        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    Min.   :-2.121
## 1st Qu.:  1.7600   1st Qu.: -88.30   1st Qu.: 3.00    1st Qu.:-1.329
## Median :  5.2800   Median : -13.00   Median :17.00    Median :-0.899
## Mean   :  0.3053   Mean   : -11.21   Mean   :11.31    Mean   :-0.220
## 3rd Qu.: 14.9000   3rd Qu.:  12.90   3rd Qu.:18.00    3rd Qu.:-0.219
## Max.   : 60.3000   Max.   : 179.00   Max.   :29.00    Max.   :33.000
##                                                       NA's   :19226
## kurtosis_picth_belt kurtosis_yaw_belt skewness_roll_belt
## Min.   :-2.190      Mode:logical      Min.   :-5.745
## 1st Qu.:-1.107      NA's:19622        1st Qu.:-0.444
## Median :-0.151                        Median : 0.000
## Mean   : 4.334                        Mean   :-0.026
## 3rd Qu.: 3.178                        3rd Qu.: 0.417
## Max.   :58.000                        Max.   : 3.595
## NA's   :19248                         NA's   :19225
## skewness_roll_belt.1 skewness_yaw_belt max_roll_belt     max_picth_belt
## Min.   :-7.616       Mode:logical      Min.   :-94.300   Min.   : 3.00
## 1st Qu.:-1.114       NA's:19622        1st Qu.:-88.000   1st Qu.: 5.00
## Median :-0.068                         Median : -5.100   Median :18.00
## Mean   :-0.296                         Mean   : -6.667   Mean   :12.92
## 3rd Qu.: 0.661                         3rd Qu.: 18.500   3rd Qu.:19.00
## Max.   : 7.348                         Max.   :180.000   Max.   :30.00
## NA's   :19248                          NA's   :19216     NA's   :19216
##   max_yaw_belt   min_roll_belt    min_pitch_belt   min_yaw_belt
## Min.   :-2.10   Min.   :-180.00   Min.   : 0.00   Min.   :-2.10
## 1st Qu.:-1.30   1st Qu.: -88.40   1st Qu.: 3.00   1st Qu.:-1.30
## Median :-0.90   Median :  -7.85   Median :16.00   Median :-0.90
## Mean   :-0.22   Mean   : -10.44   Mean   :10.76   Mean   :-0.22
## 3rd Qu.:-0.20   3rd Qu.:   9.05   3rd Qu.:17.00   3rd Qu.:-0.20
## Max.   :33.00   Max.   : 173.00   Max.   :23.00   Max.   :33.00
## NA's   :19226   NA's   :19216     NA's   :19216   NA's   :19226
```

```
##  amplitude_roll_belt amplitude_pitch_belt amplitude_yaw_belt
##  Min.   :  0.000    Min.   : 0.000      Min.   :0
##  1st Qu.:  0.300    1st Qu.: 1.000      1st Qu.:0
##  Median :  1.000    Median : 1.000      Median :0
##  Mean   :  3.769    Mean   : 2.167      Mean   :0
##  3rd Qu.:  2.083    3rd Qu.: 2.000      3rd Qu.:0
##  Max.   :360.000    Max.   :12.000      Max.   :0
##  NA's   :19216      NA's   :19216       NA's   :19226
##  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_picth_arm kurtosis_yaw_arm skewness_roll_arm
## Min.    :-1.809   Min.    :-2.084   Min.    :-2.103   Min.    :-2.541
## 1st Qu.:-1.345   1st Qu.:-1.280   1st Qu.:-1.220   1st Qu.:-0.561
## Median :-0.894   Median :-1.010   Median :-0.733   Median : 0.040
## Mean    :-0.366   Mean    :-0.542   Mean    : 0.406   Mean    : 0.068
## 3rd Qu.:-0.038   3rd Qu.:-0.379   3rd Qu.: 0.115   3rd Qu.: 0.671
## Max.    :21.456   Max.    :19.751   Max.    :56.000   Max.    : 4.394
## NA's    :19294   NA's    :19296   NA's    :19227   NA's    :19293
## skewness_pitch_arm skewness_yaw_arm max_roll_arm     max_picth_arm
## Min.    :-4.565   Min.    :-6.708   Min.    :-73.100   Min.    :-173.000
## 1st Qu.:-0.618   1st Qu.:-0.743   1st Qu.: -0.175   1st Qu.:  -1.975
## Median :-0.035   Median :-0.133   Median :  4.950   Median :  23.250
```

```
##  Mean   :-0.065     Mean   :-0.229    Mean   : 11.236    Mean   :  35.751
##  3rd Qu.: 0.454     3rd Qu.: 0.344    3rd Qu.: 26.775    3rd Qu.:  95.975
##  Max.   : 3.043     Max.   : 7.483    Max.   : 85.500    Max.   : 180.000
##  NA's   :19296      NA's   :19227     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_picth_dumbbell kurtosis_yaw_dumbbell
##  Min.   :-2.174         Min.   :-2.200          Mode:logical
##  1st Qu.:-0.682         1st Qu.:-0.721          NA's:19622
##  Median :-0.033         Median :-0.133
##  Mean   : 0.452         Mean   : 0.286
##  3rd Qu.: 0.940         3rd Qu.: 0.584
##  Max.   :54.998         Max.   :55.628
##  NA's   :19221          NA's   :19218
##  skewness_roll_dumbbell skewness_pitch_dumbbell skewness_yaw_dumbbell
##  Min.   :-7.384         Min.   :-7.447          Mode:logical
##  1st Qu.:-0.581         1st Qu.:-0.526          NA's:19622
##  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
##  max_roll_dumbbell max_picth_dumbbell max_yaw_dumbbell min_roll_dumbbell
##  Min.   :-70.10    Min.   :-112.90    Min.   :-2.20    Min.   :-149.60
##  1st Qu.:-27.15    1st Qu.: -66.70    1st Qu.:-0.70    1st Qu.: -59.67
##  Median : 14.85    Median :  40.05    Median : 0.00    Median : -43.55
##  Mean   : 13.76    Mean   :  32.75    Mean   : 0.45    Mean   : -41.24
##  3rd Qu.: 50.58    3rd Qu.: 133.22    3rd Qu.: 0.90    3rd Qu.: -25.20
##  Max.   :137.00    Max.   : 155.00    Max.   :55.00    Max.   :  73.20
##  NA's   :19216     NA's   :19216      NA's   :19221    NA's   :19216
##  min_pitch_dumbbell min_yaw_dumbbell amplitude_roll_dumbbell
##  Min.   :-147.00    Min.   :-2.20    Min.   :  0.00
```

```
##   1st Qu.: -91.80    1st Qu.:-0.70    1st Qu.: 14.97
##   Median : -66.15    Median : 0.00    Median : 35.05
##   Mean   : -33.18    Mean   : 0.45    Mean   : 55.00
##   3rd Qu.:  21.20    3rd Qu.: 0.90    3rd Qu.: 81.04
##   Max.   : 120.90    Max.   :55.00    Max.   :256.48
##   NA's   :19216      NA's   :19221    NA's   :19216
##   amplitude_pitch_dumbbell amplitude_yaw_dumbbell total_accel_dumbbell
##   Min.   :  0.00           Min.   :0              Min.   : 0.00
##   1st Qu.: 17.06           1st Qu.:0              1st Qu.: 4.00
##   Median : 41.73           Median :0              Median :10.00
##   Mean   : 65.93           Mean   :0              Mean   :13.72
##   3rd Qu.: 99.55           3rd Qu.:0              3rd Qu.:19.00
##   Max.   :273.59           Max.   :0              Max.   :58.00
##   NA's   :19216            NA's   :19221
##   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   Min.   :-1.879
##  1st Qu.:  0.00   1st Qu.: -68.60   1st Qu.:-1.398
##  Median :  9.24   Median :   0.00   Median :-1.119
##  Mean   : 10.71   Mean   :  19.21   Mean   :-0.689
##  3rd Qu.: 28.40   3rd Qu.: 110.00   3rd Qu.:-0.618
##  Max.   : 89.80   Max.   : 180.00   Max.   :40.060
##                                     NA's   :19300
##  kurtosis_picth_forearm kurtosis_yaw_forearm skewness_roll_forearm
##  Min.   :-2.098         Mode:logical         Min.   :-2.297
##  1st Qu.:-1.376         NA's:19622           1st Qu.:-0.402
##  Median :-0.890                              Median : 0.003
##  Mean   : 0.419                              Mean   :-0.009
##  3rd Qu.: 0.054                              3rd Qu.: 0.370
##  Max.   :33.626                              Max.   : 5.856
##  NA's   :19301                               NA's   :19299
##  skewness_pitch_forearm skewness_yaw_forearm max_roll_forearm
##  Min.   :-5.241         Mode:logical         Min.   :-66.60
##  1st Qu.:-0.881         NA's:19622           1st Qu.:  0.00
##  Median :-0.156                              Median : 26.80
##  Mean   :-0.223                              Mean   : 24.49
##  3rd Qu.: 0.514                              3rd Qu.: 45.95
##  Max.   : 4.464                              Max.   : 89.80
##  NA's   :19301                               NA's   :19216
##  max_picth_forearm max_yaw_forearm  min_roll_forearm   min_pitch_forearm
##  Min.   :-151.00   Min.   :-1.900   Min.   :-72.500   Min.   :-180.00
##  1st Qu.:   0.00   1st Qu.:-1.400   1st Qu.: -6.075   1st Qu.:-175.00
##  Median : 113.00   Median :-1.100   Median :  0.000   Median : -61.00
##  Mean   :  81.49   Mean   :-0.689   Mean   : -0.167   Mean   : -57.57
##  3rd Qu.: 174.75   3rd Qu.:-0.600   3rd Qu.: 12.075   3rd Qu.:   0.00
##  Max.   : 180.00   Max.   :40.100   Max.   : 62.100   Max.   : 167.00
##  NA's   :19216     NA's   :19300    NA's   :19216     NA's   :19216
##  min_yaw_forearm  amplitude_roll_forearm amplitude_pitch_forearm
##  Min.   :-1.900   Min.   :  0.000        Min.   :  0.0
##  1st Qu.:-1.400   1st Qu.:  1.125        1st Qu.:  2.0
##  Median :-1.100   Median : 17.770        Median : 83.7
##  Mean   :-0.689   Mean   : 24.653        Mean   :139.1
##  3rd Qu.:-0.600   3rd Qu.: 39.875        3rd Qu.:350.0
##  Max.   :40.100   Max.   :126.000        Max.   :360.0
##  NA's   :19300    NA's   :19216          NA's   :19216
##  amplitude_yaw_forearm total_accel_forearm var_accel_forearm
##  Min.   :0             Min.   :  0.00      Min.   :  0.000
##  1st Qu.:0             1st Qu.: 29.00      1st Qu.:  6.759
##  Median :0             Median : 36.00      Median : 21.165
##  Mean   :0             Mean   : 34.72      Mean   : 33.502
##  3rd Qu.:0             3rd Qu.: 41.00      3rd Qu.: 51.240
```

```
## Max.    :0              Max.    :108.00     Max.    :172.606
## NA's   :19300                               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
##
##
```