MachineLearningPR

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Machine Learning Peer Reviewed Project 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.

In this project, we will be looking at wearables data to try and determine in which way they did the exercise.

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.

First, we'll take a look at how to load the data and format it for analysis

```
library(caret)

## Warning: package 'caret' was built under R version 3.4.2

## Loading required package: lattice

## Loading required package: ggplot2

library(randomForest) #Random forest for classification and regression

## Warning: package 'randomForest' was built under R version 3.4.2

## randomForest 4.6-12

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

##
## Attaching package: 'randomForest'

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

## randomForest 4.6-10
## Type rfNews() to see new features/changes/bug fixes.
```

```r
library(rpart) # Regressive Partitioning and Regression trees
library(rpart.plot) # Decision Tree plot

## Warning: package 'rpart.plot' was built under R version 3.4.2

trainingdata<-
read.csv("C:/Users/Manuel/Desktop/Coursera/MachineLearning/pml-training.csv",
na.strings = c("NA",""))


testingdata<- read.csv("C:/Users/Manuel/Desktop/Coursera/MachineLearning/pml-
testing.csv", na.strings= c("NA",""))


head(trainingdata)

##   X user_name raw_timestamp_part_1 raw_timestamp_part_2   cvtd_timestamp
## 1 1  carlitos           1323084231               788290 05/12/2011 11:23
## 2 2  carlitos           1323084231               808298 05/12/2011 11:23
## 3 3  carlitos           1323084231               820366 05/12/2011 11:23
## 4 4  carlitos           1323084232               120339 05/12/2011 11:23
## 5 5  carlitos           1323084232               196328 05/12/2011 11:23
## 6 6  carlitos           1323084232               304277 05/12/2011 11:23
##   new_window num_window roll_belt pitch_belt yaw_belt total_accel_belt
## 1         no         11      1.41       8.07    -94.4                3
## 2         no         11      1.41       8.07    -94.4                3
## 3         no         11      1.42       8.07    -94.4                3
## 4         no         12      1.48       8.05    -94.4                3
## 5         no         12      1.48       8.07    -94.4                3
## 6         no         12      1.45       8.06    -94.4                3
##   kurtosis_roll_belt kurtosis_picth_belt kurtosis_yaw_belt
## 1               <NA>                <NA>              <NA>
## 2               <NA>                <NA>              <NA>
## 3               <NA>                <NA>              <NA>
## 4               <NA>                <NA>              <NA>
## 5               <NA>                <NA>              <NA>
## 6               <NA>                <NA>              <NA>
##   skewness_roll_belt skewness_roll_belt.1 skewness_yaw_belt max_roll_belt
## 1               <NA>                <NA>              <NA>            NA
## 2               <NA>                <NA>              <NA>            NA
## 3               <NA>                <NA>              <NA>            NA
## 4               <NA>                <NA>              <NA>            NA
## 5               <NA>                <NA>              <NA>            NA
## 6               <NA>                <NA>              <NA>            NA
##   max_picth_belt max_yaw_belt min_roll_belt min_pitch_belt min_yaw_belt
## 1             NA         <NA>            NA             NA         <NA>
## 2             NA         <NA>            NA             NA         <NA>
## 3             NA         <NA>            NA             NA         <NA>
## 4             NA         <NA>            NA             NA         <NA>
## 5             NA         <NA>            NA             NA         <NA>
```

```
## 6              NA         <NA>             NA              NA         <NA>
##   amplitude_roll_belt amplitude_pitch_belt amplitude_yaw_belt
## 1                  NA                   NA               <NA>
## 2                  NA                   NA               <NA>
## 3                  NA                   NA               <NA>
## 4                  NA                   NA               <NA>
## 5                  NA                   NA               <NA>
## 6                  NA                   NA               <NA>
##   var_total_accel_belt avg_roll_belt stddev_roll_belt var_roll_belt
## 1                   NA            NA                NA            NA
## 2                   NA            NA                NA            NA
## 3                   NA            NA                NA            NA
## 4                   NA            NA                NA            NA
## 5                   NA            NA                NA            NA
## 6                   NA            NA                NA            NA
##   avg_pitch_belt stddev_pitch_belt var_pitch_belt avg_yaw_belt
## 1             NA                NA             NA           NA
## 2             NA                NA             NA           NA
## 3             NA                NA             NA           NA
## 4             NA                NA             NA           NA
## 5             NA                NA             NA           NA
## 6             NA                NA             NA           NA
##   stddev_yaw_belt var_yaw_belt gyros_belt_x gyros_belt_y gyros_belt_z
## 1              NA           NA         0.00         0.00        -0.02
## 2              NA           NA         0.02         0.00        -0.02
## 3              NA           NA         0.00         0.00        -0.02
## 4              NA           NA         0.02         0.00        -0.03
## 5              NA           NA         0.02         0.02        -0.02
## 6              NA           NA         0.02         0.00        -0.02
##   accel_belt_x accel_belt_y accel_belt_z magnet_belt_x magnet_belt_y
## 1          -21            4           22            -3           599
## 2          -22            4           22            -7           608
## 3          -20            5           23            -2           600
## 4          -22            3           21            -6           604
## 5          -21            2           24            -6           600
## 6          -21            4           21             0           603
##   magnet_belt_z roll_arm pitch_arm yaw_arm total_accel_arm var_accel_arm
## 1          -313     -128      22.5    -161              34            NA
## 2          -311     -128      22.5    -161              34            NA
## 3          -305     -128      22.5    -161              34            NA
## 4          -310     -128      22.1    -161              34            NA
## 5          -302     -128      22.1    -161              34            NA
## 6          -312     -128      22.0    -161              34            NA
##   avg_roll_arm stddev_roll_arm var_roll_arm avg_pitch_arm stddev_pitch_arm
## 1           NA              NA           NA            NA               NA
## 2           NA              NA           NA            NA               NA
## 3           NA              NA           NA            NA               NA
## 4           NA              NA           NA            NA               NA
## 5           NA              NA           NA            NA               NA
## 6           NA              NA           NA            NA               NA
```

```
##   var_pitch_arm avg_yaw_arm stddev_yaw_arm var_yaw_arm gyros_arm_x
## 1            NA          NA             NA          NA        0.00
## 2            NA          NA             NA          NA        0.02
## 3            NA          NA             NA          NA        0.02
## 4            NA          NA             NA          NA        0.02
## 5            NA          NA             NA          NA        0.00
## 6            NA          NA             NA          NA        0.02
##   gyros_arm_y gyros_arm_z accel_arm_x accel_arm_y accel_arm_z magnet_arm_x
## 1        0.00       -0.02        -288         109        -123         -368
## 2       -0.02       -0.02        -290         110        -125         -369
## 3       -0.02       -0.02        -289         110        -126         -368
## 4       -0.03        0.02        -289         111        -123         -372
## 5       -0.03        0.00        -289         111        -123         -374
## 6       -0.03        0.00        -289         111        -122         -369
##   magnet_arm_y magnet_arm_z kurtosis_roll_arm kurtosis_picth_arm
## 1          337          516              <NA>               <NA>
## 2          337          513              <NA>               <NA>
## 3          344          513              <NA>               <NA>
## 4          344          512              <NA>               <NA>
## 5          337          506              <NA>               <NA>
## 6          342          513              <NA>               <NA>
##   kurtosis_yaw_arm skewness_roll_arm skewness_pitch_arm skewness_yaw_arm
## 1             <NA>              <NA>               <NA>             <NA>
## 2             <NA>              <NA>               <NA>             <NA>
## 3             <NA>              <NA>               <NA>             <NA>
## 4             <NA>              <NA>               <NA>             <NA>
## 5             <NA>              <NA>               <NA>             <NA>
## 6             <NA>              <NA>               <NA>             <NA>
##   max_roll_arm max_picth_arm max_yaw_arm min_roll_arm min_pitch_arm
## 1           NA            NA          NA           NA            NA
## 2           NA            NA          NA           NA            NA
## 3           NA            NA          NA           NA            NA
## 4           NA            NA          NA           NA            NA
## 5           NA            NA          NA           NA            NA
## 6           NA            NA          NA           NA            NA
##   min_yaw_arm amplitude_roll_arm amplitude_pitch_arm amplitude_yaw_arm
## 1          NA                NA                  NA                NA
## 2          NA                NA                  NA                NA
## 3          NA                NA                  NA                NA
## 4          NA                NA                  NA                NA
## 5          NA                NA                  NA                NA
## 6          NA                NA                  NA                NA
##   roll_dumbbell pitch_dumbbell yaw_dumbbell kurtosis_roll_dumbbell
## 1      13.05217      -70.49400    -84.87394                   <NA>
## 2      13.13074      -70.63751    -84.71065                   <NA>
## 3      12.85075      -70.27812    -85.14078                   <NA>
## 4      13.43120      -70.39379    -84.87363                   <NA>
## 5      13.37872      -70.42856    -84.85306                   <NA>
## 6      13.38246      -70.81759    -84.46500                   <NA>
##   kurtosis_picth_dumbbell kurtosis_yaw_dumbbell skewness_roll_dumbbell
```

```
## 1                    <NA>                    <NA>                    <NA>
## 2                    <NA>                    <NA>                    <NA>
## 3                    <NA>                    <NA>                    <NA>
## 4                    <NA>                    <NA>                    <NA>
## 5                    <NA>                    <NA>                    <NA>
## 6                    <NA>                    <NA>                    <NA>
##   skewness_pitch_dumbbell skewness_yaw_dumbbell max_roll_dumbbell
## 1                    <NA>                    <NA>                NA
## 2                    <NA>                    <NA>                NA
## 3                    <NA>                    <NA>                NA
## 4                    <NA>                    <NA>                NA
## 5                    <NA>                    <NA>                NA
## 6                    <NA>                    <NA>                NA
##   max_picth_dumbbell max_yaw_dumbbell min_roll_dumbbell min_pitch_dumbbell
## 1                 NA             <NA>                NA                 NA
## 2                 NA             <NA>                NA                 NA
## 3                 NA             <NA>                NA                 NA
## 4                 NA             <NA>                NA                 NA
## 5                 NA             <NA>                NA                 NA
## 6                 NA             <NA>                NA                 NA
##   min_yaw_dumbbell amplitude_roll_dumbbell amplitude_pitch_dumbbell
## 1             <NA>                       NA                       NA
## 2             <NA>                       NA                       NA
## 3             <NA>                       NA                       NA
## 4             <NA>                       NA                       NA
## 5             <NA>                       NA                       NA
## 6             <NA>                       NA                       NA
##   amplitude_yaw_dumbbell total_accel_dumbbell var_accel_dumbbell
## 1                   <NA>                    37                NA
## 2                   <NA>                    37                NA
## 3                   <NA>                    37                NA
## 4                   <NA>                    37                NA
## 5                   <NA>                    37                NA
## 6                   <NA>                    37                NA
##   avg_roll_dumbbell stddev_roll_dumbbell var_roll_dumbbell
## 1                NA                   NA                NA
## 2                NA                   NA                NA
## 3                NA                   NA                NA
## 4                NA                   NA                NA
## 5                NA                   NA                NA
## 6                NA                   NA                NA
##   avg_pitch_dumbbell stddev_pitch_dumbbell var_pitch_dumbbell
## 1                 NA                    NA                 NA
## 2                 NA                    NA                 NA
## 3                 NA                    NA                 NA
## 4                 NA                    NA                 NA
## 5                 NA                    NA                 NA
## 6                 NA                    NA                 NA
##   avg_yaw_dumbbell stddev_yaw_dumbbell var_yaw_dumbbell gyros_dumbbell_x
## 1               NA                  NA                NA                0
```

```
## 2               NA                  NA               NA                0
## 3               NA                  NA               NA                0
## 4               NA                  NA               NA                0
## 5               NA                  NA               NA                0
## 6               NA                  NA               NA                0
##   gyros_dumbbell_y gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y
## 1            -0.02             0.00             -234               47
## 2            -0.02             0.00             -233               47
## 3            -0.02             0.00             -232               46
## 4            -0.02            -0.02             -232               48
## 5            -0.02             0.00             -233               48
## 6            -0.02             0.00             -234               48
##   accel_dumbbell_z magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z
## 1             -271              -559               293               -65
## 2             -269              -555               296               -64
## 3             -270              -561               298               -63
## 4             -269              -552               303               -60
## 5             -270              -554               292               -68
## 6             -269              -558               294               -66
##   roll_forearm pitch_forearm yaw_forearm kurtosis_roll_forearm
## 1         28.4         -63.9        -153                 <NA>
## 2         28.3         -63.9        -153                 <NA>
## 3         28.3         -63.9        -152                 <NA>
## 4         28.1         -63.9        -152                 <NA>
## 5         28.0         -63.9        -152                 <NA>
## 6         27.9         -63.9        -152                 <NA>
##   kurtosis_picth_forearm kurtosis_yaw_forearm skewness_roll_forearm
## 1                   <NA>                 <NA>                  <NA>
## 2                   <NA>                 <NA>                  <NA>
## 3                   <NA>                 <NA>                  <NA>
## 4                   <NA>                 <NA>                  <NA>
## 5                   <NA>                 <NA>                  <NA>
## 6                   <NA>                 <NA>                  <NA>
##   skewness_pitch_forearm skewness_yaw_forearm max_roll_forearm
## 1                   <NA>                 <NA>               NA
## 2                   <NA>                 <NA>               NA
## 3                   <NA>                 <NA>               NA
## 4                   <NA>                 <NA>               NA
## 5                   <NA>                 <NA>               NA
## 6                   <NA>                 <NA>               NA
##   max_picth_forearm max_yaw_forearm min_roll_forearm min_pitch_forearm
## 1                NA            <NA>               NA                NA
## 2                NA            <NA>               NA                NA
## 3                NA            <NA>               NA                NA
## 4                NA            <NA>               NA                NA
## 5                NA            <NA>               NA                NA
## 6                NA            <NA>               NA                NA
##   min_yaw_forearm amplitude_roll_forearm amplitude_pitch_forearm
## 1            <NA>                    NA                     NA
## 2            <NA>                    NA                     NA
```

```
## 3            <NA>                    NA                     NA
## 4            <NA>                    NA                     NA
## 5            <NA>                    NA                     NA
## 6            <NA>                    NA                     NA
##   amplitude_yaw_forearm total_accel_forearm var_accel_forearm
## 1                  <NA>                  36                NA
## 2                  <NA>                  36                NA
## 3                  <NA>                  36                NA
## 4                  <NA>                  36                NA
## 5                  <NA>                  36                NA
## 6                  <NA>                  36                NA
##   avg_roll_forearm stddev_roll_forearm var_roll_forearm avg_pitch_forearm
## 1               NA                  NA                NA                NA
## 2               NA                  NA                NA                NA
## 3               NA                  NA                NA                NA
## 4               NA                  NA                NA                NA
## 5               NA                  NA                NA                NA
## 6               NA                  NA                NA                NA
##   stddev_pitch_forearm var_pitch_forearm avg_yaw_forearm
## 1                   NA                NA               NA
## 2                   NA                NA               NA
## 3                   NA                NA               NA
## 4                   NA                NA               NA
## 5                   NA                NA               NA
## 6                   NA                NA               NA
##   stddev_yaw_forearm var_yaw_forearm gyros_forearm_x gyros_forearm_y
## 1                 NA              NA            0.03            0.00
## 2                 NA              NA            0.02            0.00
## 3                 NA              NA            0.03           -0.02
## 4                 NA              NA            0.02           -0.02
## 5                 NA              NA            0.02            0.00
## 6                 NA              NA            0.02           -0.02
##   gyros_forearm_z accel_forearm_x accel_forearm_y accel_forearm_z
## 1           -0.02             192             203            -215
## 2           -0.02             192             203            -216
## 3            0.00             196             204            -213
## 4            0.00             189             206            -214
## 5           -0.02             189             206            -214
## 6           -0.03             193             203            -215
##   magnet_forearm_x magnet_forearm_y magnet_forearm_z classe
## 1              -17              654              476      A
## 2              -18              661              473      A
## 3              -18              658              469      A
## 4              -16              658              469      A
## 5              -17              655              473      A
## 6               -9              660              478      A
```

```
head(testingdata)
```

```
##   X user_name raw_timestamp_part_1 raw_timestamp_part_2   cvtd_timestamp
## 1 1     pedro           1323095002               868349 05/12/2011 14:23
## 2 2    jeremy           1322673067               778725 30/11/2011 17:11
## 3 3    jeremy           1322673075               342967 30/11/2011 17:11
## 4 4    adelmo           1322832789               560311 02/12/2011 13:33
## 5 5    eurico           1322489635               814776 28/11/2011 14:13
## 6 6    jeremy           1322673149               510661 30/11/2011 17:12
##   new_window num_window roll_belt pitch_belt yaw_belt total_accel_belt
## 1         no         74    123.00      27.00    -4.75               20
## 2         no        431      1.02       4.87   -88.90                4
## 3         no        439      0.87       1.82   -88.50                5
## 4         no        194    125.00     -41.60   162.00               17
## 5         no        235      1.35       3.33   -88.60                3
## 6         no        504     -5.92       1.59   -87.70                4
##   kurtosis_roll_belt kurtosis_picth_belt kurtosis_yaw_belt
## 1                 NA                  NA                NA
## 2                 NA                  NA                NA
## 3                 NA                  NA                NA
## 4                 NA                  NA                NA
## 5                 NA                  NA                NA
## 6                 NA                  NA                NA
##   skewness_roll_belt skewness_roll_belt.1 skewness_yaw_belt max_roll_belt
## 1                 NA                   NA                NA            NA
## 2                 NA                   NA                NA            NA
## 3                 NA                   NA                NA            NA
## 4                 NA                   NA                NA            NA
## 5                 NA                   NA                NA            NA
## 6                 NA                   NA                NA            NA
##   max_picth_belt max_yaw_belt min_roll_belt min_pitch_belt min_yaw_belt
## 1             NA           NA            NA             NA           NA
## 2             NA           NA            NA             NA           NA
## 3             NA           NA            NA             NA           NA
## 4             NA           NA            NA             NA           NA
## 5             NA           NA            NA             NA           NA
## 6             NA           NA            NA             NA           NA
##   amplitude_roll_belt amplitude_pitch_belt amplitude_yaw_belt
## 1                  NA                   NA                 NA
## 2                  NA                   NA                 NA
## 3                  NA                   NA                 NA
## 4                  NA                   NA                 NA
## 5                  NA                   NA                 NA
## 6                  NA                   NA                 NA
##   var_total_accel_belt avg_roll_belt stddev_roll_belt var_roll_belt
## 1                   NA            NA                NA            NA
## 2                   NA            NA                NA            NA
## 3                   NA            NA                NA            NA
## 4                   NA            NA                NA            NA
## 5                   NA            NA                NA            NA
## 6                   NA            NA                NA            NA
##   avg_pitch_belt stddev_pitch_belt var_pitch_belt avg_yaw_belt
```

```
## 1             NA                NA             NA           NA
## 2             NA                NA             NA           NA
## 3             NA                NA             NA           NA
## 4             NA                NA             NA           NA
## 5             NA                NA             NA           NA
## 6             NA                NA             NA           NA
##   stddev_yaw_belt var_yaw_belt gyros_belt_x gyros_belt_y gyros_belt_z
## 1              NA           NA        -0.50        -0.02        -0.46
## 2              NA           NA        -0.06        -0.02        -0.07
## 3              NA           NA         0.05         0.02         0.03
## 4              NA           NA         0.11         0.11        -0.16
## 5              NA           NA         0.03         0.02         0.00
## 6              NA           NA         0.10         0.05        -0.13
##   accel_belt_x accel_belt_y accel_belt_z magnet_belt_x magnet_belt_y
## 1          -38           69         -179           -13           581
## 2          -13           11           39            43           636
## 3            1           -1           49            29           631
## 4           46           45         -156           169           608
## 5           -8            4           27            33           566
## 6          -11          -16           38            31           638
##   magnet_belt_z roll_arm pitch_arm yaw_arm total_accel_arm var_accel_arm
## 1          -382     40.7    -27.80     178              10            NA
## 2          -309      0.0      0.00       0              38            NA
## 3          -312      0.0      0.00       0              44            NA
## 4          -304   -109.0     55.00    -142              25            NA
## 5          -418     76.1      2.76     102              29            NA
## 6          -291      0.0      0.00       0              14            NA
##   avg_roll_arm stddev_roll_arm var_roll_arm avg_pitch_arm stddev_pitch_arm
## 1           NA              NA           NA            NA               NA
## 2           NA              NA           NA            NA               NA
## 3           NA              NA           NA            NA               NA
## 4           NA              NA           NA            NA               NA
## 5           NA              NA           NA            NA               NA
## 6           NA              NA           NA            NA               NA
##   var_pitch_arm avg_yaw_arm stddev_yaw_arm var_yaw_arm gyros_arm_x
## 1            NA          NA             NA          NA       -1.65
## 2            NA          NA             NA          NA       -1.17
## 3            NA          NA             NA          NA        2.10
## 4            NA          NA             NA          NA        0.22
## 5            NA          NA             NA          NA       -1.96
## 6            NA          NA             NA          NA        0.02
##   gyros_arm_y gyros_arm_z accel_arm_x accel_arm_y accel_arm_z magnet_arm_x
## 1        0.48       -0.18          16          38          93         -326
## 2        0.85       -0.43        -290         215         -90         -325
## 3       -1.36        1.13        -341         245         -87         -264
## 4       -0.51        0.92        -238         -57           6         -173
## 5        0.79       -0.54        -197         200         -30         -170
## 6        0.05       -0.07         -26         130         -19          396
##   magnet_arm_y magnet_arm_z kurtosis_roll_arm kurtosis_picth_arm
## 1          385          481                NA                 NA
```

```
## 2          447          434                NA                NA
## 3          474          413                NA                NA
## 4          257          633                NA                NA
## 5          275          617                NA                NA
## 6          176          516                NA                NA
##   kurtosis_yaw_arm skewness_roll_arm skewness_pitch_arm skewness_yaw_arm
## 1               NA                NA                 NA               NA
## 2               NA                NA                 NA               NA
## 3               NA                NA                 NA               NA
## 4               NA                NA                 NA               NA
## 5               NA                NA                 NA               NA
## 6               NA                NA                 NA               NA
##   max_roll_arm max_picth_arm max_yaw_arm min_roll_arm min_pitch_arm
## 1           NA            NA          NA           NA            NA
## 2           NA            NA          NA           NA            NA
## 3           NA            NA          NA           NA            NA
## 4           NA            NA          NA           NA            NA
## 5           NA            NA          NA           NA            NA
## 6           NA            NA          NA           NA            NA
##   min_yaw_arm amplitude_roll_arm amplitude_pitch_arm amplitude_yaw_arm
## 1          NA                NA                 NA               NA
## 2          NA                NA                 NA               NA
## 3          NA                NA                 NA               NA
## 4          NA                NA                 NA               NA
## 5          NA                NA                 NA               NA
## 6          NA                NA                 NA               NA
##   roll_dumbbell pitch_dumbbell yaw_dumbbell kurtosis_roll_dumbbell
## 1     -17.73748       24.96085    126.23596                     NA
## 2      54.47761      -53.69758    -75.51480                     NA
## 3      57.07031      -51.37303    -75.20287                     NA
## 4      43.10927      -30.04885   -103.32003                     NA
## 5    -101.38396      -53.43952    -14.19542                     NA
## 6      62.18750      -50.55595    -71.12063                     NA
##   kurtosis_picth_dumbbell kurtosis_yaw_dumbbell skewness_roll_dumbbell
## 1                      NA                    NA                     NA
## 2                      NA                    NA                     NA
## 3                      NA                    NA                     NA
## 4                      NA                    NA                     NA
## 5                      NA                    NA                     NA
## 6                      NA                    NA                     NA
##   skewness_pitch_dumbbell skewness_yaw_dumbbell max_roll_dumbbell
## 1                      NA                    NA                NA
## 2                      NA                    NA                NA
## 3                      NA                    NA                NA
## 4                      NA                    NA                NA
## 5                      NA                    NA                NA
## 6                      NA                    NA                NA
##   max_picth_dumbbell max_yaw_dumbbell min_roll_dumbbell min_pitch_dumbbell
## 1                 NA               NA                NA                 NA
## 2                 NA               NA                NA                 NA
```

```
## 3                 NA                NA                NA                NA
## 4                 NA                NA                NA                NA
## 5                 NA                NA                NA                NA
## 6                 NA                NA                NA                NA
##   min_yaw_dumbbell amplitude_roll_dumbbell amplitude_pitch_dumbbell
## 1               NA                      NA                       NA
## 2               NA                      NA                       NA
## 3               NA                      NA                       NA
## 4               NA                      NA                       NA
## 5               NA                      NA                       NA
## 6               NA                      NA                       NA
##   amplitude_yaw_dumbbell total_accel_dumbbell var_accel_dumbbell
## 1                     NA                    9                 NA
## 2                     NA                   31                 NA
## 3                     NA                   29                 NA
## 4                     NA                   18                 NA
## 5                     NA                    4                 NA
## 6                     NA                   29                 NA
##   avg_roll_dumbbell stddev_roll_dumbbell var_roll_dumbbell
## 1                NA                   NA                NA
## 2                NA                   NA                NA
## 3                NA                   NA                NA
## 4                NA                   NA                NA
## 5                NA                   NA                NA
## 6                NA                   NA                NA
##   avg_pitch_dumbbell stddev_pitch_dumbbell var_pitch_dumbbell
## 1                 NA                    NA                 NA
## 2                 NA                    NA                 NA
## 3                 NA                    NA                 NA
## 4                 NA                    NA                 NA
## 5                 NA                    NA                 NA
## 6                 NA                    NA                 NA
##   avg_yaw_dumbbell stddev_yaw_dumbbell var_yaw_dumbbell gyros_dumbbell_x
## 1               NA                  NA               NA             0.64
## 2               NA                  NA               NA             0.34
## 3               NA                  NA               NA             0.39
## 4               NA                  NA               NA             0.10
## 5               NA                  NA               NA             0.29
## 6               NA                  NA               NA            -0.59
##   gyros_dumbbell_y gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y
## 1             0.06            -0.61               21              -15
## 2             0.05            -0.71             -153              155
## 3             0.14            -0.34             -141              155
## 4            -0.02             0.05              -51               72
## 5            -0.47            -0.46              -18              -30
## 6             0.80             1.10             -138              166
##   accel_dumbbell_z magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z
## 1               81               523              -528               -56
## 2             -205              -502               388               -36
## 3             -196              -506               349                41
```

```
## 4             -148              -576               238                53
## 5               -5              -424               252               312
## 6             -186              -543               262                96
##   roll_forearm pitch_forearm yaw_forearm kurtosis_roll_forearm
## 1          141         49.30       156.0                    NA
## 2          109        -17.60       106.0                    NA
## 3          131        -32.60        93.0                    NA
## 4            0          0.00         0.0                    NA
## 5         -176         -2.16       -47.9                    NA
## 6          150          1.46        89.7                    NA
##   kurtosis_picth_forearm kurtosis_yaw_forearm skewness_roll_forearm
## 1                     NA                   NA                    NA
## 2                     NA                   NA                    NA
## 3                     NA                   NA                    NA
## 4                     NA                   NA                    NA
## 5                     NA                   NA                    NA
## 6                     NA                   NA                    NA
##   skewness_pitch_forearm skewness_yaw_forearm max_roll_forearm
## 1                     NA                   NA                NA
## 2                     NA                   NA                NA
## 3                     NA                   NA                NA
## 4                     NA                   NA                NA
## 5                     NA                   NA                NA
## 6                     NA                   NA                NA
##   max_picth_forearm max_yaw_forearm min_roll_forearm min_pitch_forearm
## 1                NA              NA               NA                NA
## 2                NA              NA               NA                NA
## 3                NA              NA               NA                NA
## 4                NA              NA               NA                NA
## 5                NA              NA               NA                NA
## 6                NA              NA               NA                NA
##   min_yaw_forearm amplitude_roll_forearm amplitude_pitch_forearm
## 1              NA                     NA                      NA
## 2              NA                     NA                      NA
## 3              NA                     NA                      NA
## 4              NA                     NA                      NA
## 5              NA                     NA                      NA
## 6              NA                     NA                      NA
##   amplitude_yaw_forearm total_accel_forearm var_accel_forearm
## 1                    NA                  33                NA
## 2                    NA                  39                NA
## 3                    NA                  34                NA
## 4                    NA                  43                NA
## 5                    NA                  24                NA
## 6                    NA                  43                NA
##   avg_roll_forearm stddev_roll_forearm var_roll_forearm avg_pitch_forearm
## 1               NA                  NA               NA                NA
## 2               NA                  NA               NA                NA
## 3               NA                  NA               NA                NA
## 4               NA                  NA               NA                NA
```

```
## 5                NA                   NA                NA                   NA
## 6                NA                   NA                NA                   NA
##   stddev_pitch_forearm var_pitch_forearm avg_yaw_forearm
## 1                   NA                NA               NA
## 2                   NA                NA               NA
## 3                   NA                NA               NA
## 4                   NA                NA               NA
## 5                   NA                NA               NA
## 6                   NA                NA               NA
##   stddev_yaw_forearm var_yaw_forearm gyros_forearm_x gyros_forearm_y
## 1                 NA              NA            0.74           -3.34
## 2                 NA              NA            1.12           -2.78
## 3                 NA              NA            0.18           -0.79
## 4                 NA              NA            1.38            0.69
## 5                 NA              NA           -0.75            3.10
## 6                 NA              NA           -0.88            4.26
##   gyros_forearm_z accel_forearm_x accel_forearm_y accel_forearm_z
## 1           -0.59            -110             267            -149
## 2           -0.18             212             297            -118
## 3            0.28             154             271            -129
## 4            1.80             -92             406             -39
## 5            0.80             131             -93             172
## 6            1.35             230             322            -144
##   magnet_forearm_x magnet_forearm_y magnet_forearm_z problem_id
## 1             -714              419              617          1
## 2             -237              791              873          2
## 3              -51              698              783          3
## 4             -233              783              521          4
## 5              375             -787               91          5
## 6             -300              800              884          6
```

```
#Then, We try to clear all the NA values in the data
trainingdata<- trainingdata[,colSums(is.na(trainingdata))==0]
testingdata<-testingdata[,colSums(is.na(testingdata))==0]

#Also, since we will not be using all of the data. We eliminate the data that
we will not be using
trainingdata   <-trainingdata[,-c(1:7)]
testingdata <-testingdata[,-c(1:7)]
```

After formatting, we take a look at the newly formatted data:

```
dim(trainingdata)
```

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

```
dim(testingdata)
```

```
## [1] 20 53
```

```
head(trainingdata)
```

```
##   roll_belt pitch_belt yaw_belt total_accel_belt gyros_belt_x gyros_belt_y
## 1      1.41       8.07    -94.4                3         0.00         0.00
## 2      1.41       8.07    -94.4                3         0.02         0.00
## 3      1.42       8.07    -94.4                3         0.00         0.00
## 4      1.48       8.05    -94.4                3         0.02         0.00
## 5      1.48       8.07    -94.4                3         0.02         0.02
## 6      1.45       8.06    -94.4                3         0.02         0.00
##   gyros_belt_z accel_belt_x accel_belt_y accel_belt_z magnet_belt_x
## 1        -0.02          -21            4           22            -3
## 2        -0.02          -22            4           22            -7
## 3        -0.02          -20            5           23            -2
## 4        -0.03          -22            3           21            -6
## 5        -0.02          -21            2           24            -6
## 6        -0.02          -21            4           21             0
##   magnet_belt_y magnet_belt_z roll_arm pitch_arm yaw_arm total_accel_arm
## 1           599          -313     -128      22.5    -161              34
## 2           608          -311     -128      22.5    -161              34
## 3           600          -305     -128      22.5    -161              34
## 4           604          -310     -128      22.1    -161              34
## 5           600          -302     -128      22.1    -161              34
## 6           603          -312     -128      22.0    -161              34
##   gyros_arm_x gyros_arm_y gyros_arm_z accel_arm_x accel_arm_y accel_arm_z
## 1        0.00        0.00       -0.02        -288         109        -123
## 2        0.02       -0.02       -0.02        -290         110        -125
## 3        0.02       -0.02       -0.02        -289         110        -126
## 4        0.02       -0.03        0.02        -289         111        -123
## 5        0.00       -0.03        0.00        -289         111        -123
## 6        0.02       -0.03        0.00        -289         111        -122
##   magnet_arm_x magnet_arm_y magnet_arm_z roll_dumbbell pitch_dumbbell
## 1         -368          337          516      13.05217      -70.49400
## 2         -369          337          513      13.13074      -70.63751
## 3         -368          344          513      12.85075      -70.27812
## 4         -372          344          512      13.43120      -70.39379
## 5         -374          337          506      13.37872      -70.42856
## 6         -369          342          513      13.38246      -70.81759
##   yaw_dumbbell total_accel_dumbbell gyros_dumbbell_x gyros_dumbbell_y
## 1    -84.87394                   37                0            -0.02
## 2    -84.71065                   37                0            -0.02
## 3    -85.14078                   37                0            -0.02
## 4    -84.87363                   37                0            -0.02
## 5    -84.85306                   37                0            -0.02
## 6    -84.46500                   37                0            -0.02
##   gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y accel_dumbbell_z
## 1             0.00             -234               47             -271
## 2             0.00             -233               47             -269
## 3             0.00             -232               46             -270
## 4            -0.02             -232               48             -269
## 5             0.00             -233               48             -270
## 6             0.00             -234               48             -269
##   magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z roll_forearm
```

```
## 1              -559               293               -65         28.4
## 2              -555               296               -64         28.3
## 3              -561               298               -63         28.3
## 4              -552               303               -60         28.1
## 5              -554               292               -68         28.0
## 6              -558               294               -66         27.9
##   pitch_forearm yaw_forearm total_accel_forearm gyros_forearm_x
## 1         -63.9        -153                  36            0.03
## 2         -63.9        -153                  36            0.02
## 3         -63.9        -152                  36            0.03
## 4         -63.9        -152                  36            0.02
## 5         -63.9        -152                  36            0.02
## 6         -63.9        -152                  36            0.02
##   gyros_forearm_y gyros_forearm_z accel_forearm_x accel_forearm_y
## 1            0.00           -0.02             192             203
## 2            0.00           -0.02             192             203
## 3           -0.02            0.00             196             204
## 4           -0.02            0.00             189             206
## 5            0.00           -0.02             189             206
## 6           -0.02           -0.03             193             203
##   accel_forearm_z magnet_forearm_x magnet_forearm_y magnet_forearm_z
## 1            -215              -17               654               476
## 2            -216              -18               661               473
## 3            -213              -18               658               469
## 4            -214              -16               658               469
## 5            -214              -17               655               473
## 6            -215               -9               660               478
##   classe
## 1      A
## 2      A
## 3      A
## 4      A
## 5      A
## 6      A
```

```
head(testingdata)
```

```
##   roll_belt pitch_belt yaw_belt total_accel_belt gyros_belt_x gyros_belt_y
## 1    123.00      27.00    -4.75               20        -0.50        -0.02
## 2      1.02       4.87   -88.90                4        -0.06        -0.02
## 3      0.87       1.82   -88.50                5         0.05         0.02
## 4    125.00     -41.60   162.00               17         0.11         0.11
## 5      1.35       3.33   -88.60                3         0.03         0.02
## 6     -5.92       1.59   -87.70                4         0.10         0.05
##   gyros_belt_z accel_belt_x accel_belt_y accel_belt_z magnet_belt_x
## 1        -0.46          -38           69         -179           -13
## 2        -0.07          -13           11           39            43
## 3         0.03            1           -1           49            29
## 4        -0.16           46           45         -156           169
## 5         0.00           -8            4           27            33
```

```
## 6        -0.13          -11          -16           38            31
##   magnet_belt_y magnet_belt_z roll_arm pitch_arm yaw_arm total_accel_arm
## 1           581          -382     40.7    -27.80     178             10
## 2           636          -309      0.0      0.00       0             38
## 3           631          -312      0.0      0.00       0             44
## 4           608          -304   -109.0     55.00    -142             25
## 5           566          -418     76.1      2.76     102             29
## 6           638          -291      0.0      0.00       0             14
##   gyros_arm_x gyros_arm_y gyros_arm_z accel_arm_x accel_arm_y accel_arm_z
## 1       -1.65        0.48       -0.18          16          38          93
## 2       -1.17        0.85       -0.43        -290         215         -90
## 3        2.10       -1.36        1.13        -341         245         -87
## 4        0.22       -0.51        0.92        -238         -57           6
## 5       -1.96        0.79       -0.54        -197         200         -30
## 6        0.02        0.05       -0.07         -26         130         -19
##   magnet_arm_x magnet_arm_y magnet_arm_z roll_dumbbell pitch_dumbbell
## 1         -326          385          481     -17.73748       24.96085
## 2         -325          447          434      54.47761      -53.69758
## 3         -264          474          413      57.07031      -51.37303
## 4         -173          257          633      43.10927      -30.04885
## 5         -170          275          617    -101.38396      -53.43952
## 6          396          176          516      62.18750      -50.55595
##   yaw_dumbbell total_accel_dumbbell gyros_dumbbell_x gyros_dumbbell_y
## 1    126.23596                    9             0.64             0.06
## 2    -75.51480                   31             0.34             0.05
## 3    -75.20287                   29             0.39             0.14
## 4   -103.32003                   18             0.10            -0.02
## 5    -14.19542                    4             0.29            -0.47
## 6    -71.12063                   29            -0.59             0.80
##   gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y accel_dumbbell_z
## 1            -0.61               21              -15               81
## 2            -0.71             -153              155             -205
## 3            -0.34             -141              155             -196
## 4             0.05              -51               72             -148
## 5            -0.46              -18              -30               -5
## 6             1.10             -138              166             -186
##   magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z roll_forearm
## 1               523              -528               -56          141
## 2              -502               388               -36          109
## 3              -506               349                41          131
## 4              -576               238                53            0
## 5              -424               252               312         -176
## 6              -543               262                96          150
##   pitch_forearm yaw_forearm total_accel_forearm gyros_forearm_x
## 1         49.30       156.0                  33            0.74
## 2        -17.60       106.0                  39            1.12
## 3        -32.60        93.0                  34            0.18
## 4          0.00         0.0                  43            1.38
## 5         -2.16       -47.9                  24           -0.75
## 6          1.46        89.7                  43           -0.88
```

```
##   gyros_forearm_y gyros_forearm_z accel_forearm_x accel_forearm_y
## 1           -3.34           -0.59            -110             267
## 2           -2.78           -0.18             212             297
## 3           -0.79            0.28             154             271
## 4            0.69            1.80             -92             406
## 5            3.10            0.80             131             -93
## 6            4.26            1.35             230             322
##   accel_forearm_z magnet_forearm_x magnet_forearm_y magnet_forearm_z
## 1            -149             -714              419              617
## 2            -118             -237              791              873
## 3            -129              -51              698              783
## 4             -39             -233              783              521
## 5             172              375             -787               91
## 6            -144             -300              800              884
##   problem_id
## 1          1
## 2          2
## 3          3
## 4          4
## 5          5
## 6          6
```

```
summary(trainingdata)
```

```
##    roll_belt        pitch_belt          yaw_belt       total_accel_belt
##  Min.   :-28.90   Min.   :-55.8000   Min.   :-180.00   Min.   : 0.00
##  1st Qu.:  1.10   1st Qu.:  1.7600   1st Qu.: -88.30   1st Qu.: 3.00
##  Median :113.00   Median :  5.2800   Median : -13.00   Median :17.00
##  Mean   : 64.41   Mean   :  0.3053   Mean   : -11.21   Mean   :11.31
##  3rd Qu.:123.00   3rd Qu.: 14.9000   3rd Qu.:  12.90   3rd Qu.:18.00
##  Max.   :162.00   Max.   : 60.3000   Max.   : 179.00   Max.   :29.00
##   gyros_belt_x        gyros_belt_y       gyros_belt_z
##  Min.   :-1.040000   Min.   :-0.64000   Min.   :-1.4600
##  1st Qu.:-0.030000   1st Qu.: 0.00000   1st Qu.:-0.2000
##  Median : 0.030000   Median : 0.02000   Median :-0.1000
##  Mean   :-0.005592   Mean   : 0.03959   Mean   :-0.1305
##  3rd Qu.: 0.110000   3rd Qu.: 0.11000   3rd Qu.:-0.0200
##  Max.   : 2.220000   Max.   : 0.64000   Max.   : 1.6200
##   accel_belt_x       accel_belt_y     accel_belt_z     magnet_belt_x
##  Min.   :-120.000   Min.   :-69.00   Min.   :-275.00   Min.   :-52.0
##  1st Qu.: -21.000   1st Qu.:  3.00   1st Qu.:-162.00   1st Qu.:  9.0
##  Median : -15.000   Median : 35.00   Median :-152.00   Median : 35.0
##  Mean   :  -5.595   Mean   : 30.15   Mean   : -72.59   Mean   : 55.6
##  3rd Qu.:  -5.000   3rd Qu.: 61.00   3rd Qu.:  27.00   3rd Qu.: 59.0
##  Max.   :  85.000   Max.   :164.00   Max.   : 105.00   Max.   :485.0
##  magnet_belt_y   magnet_belt_z       roll_arm         pitch_arm
##  Min.   :354.0   Min.   :-623.0   Min.   :-180.00   Min.   :-88.800
##  1st Qu.:581.0   1st Qu.:-375.0   1st Qu.: -31.77   1st Qu.:-25.900
##  Median :601.0   Median :-320.0   Median :   0.00   Median :  0.000
##  Mean   :593.7   Mean   :-345.5   Mean   :  17.83   Mean   : -4.612
```

```
##  3rd Qu.:610.0   3rd Qu.:-306.0   3rd Qu.:  77.30   3rd Qu.: 11.200
##  Max.   :673.0   Max.   : 293.0   Max.   : 180.00   Max.   : 88.500
##     yaw_arm          total_accel_arm  gyros_arm_x        gyros_arm_y
##  Min.   :-180.0000   Min.   : 1.00   Min.   :-6.37000   Min.   :-3.4400
##  1st Qu.: -43.1000   1st Qu.:17.00   1st Qu.:-1.33000   1st Qu.:-0.8000
##  Median :   0.0000   Median :27.00   Median : 0.08000   Median :-0.2400
##  Mean   :  -0.6188   Mean   :25.51   Mean   : 0.04277   Mean   :-0.2571
##  3rd Qu.:  45.8750   3rd Qu.:33.00   3rd Qu.: 1.57000   3rd Qu.: 0.1400
##  Max.   : 180.0000   Max.   :66.00   Max.   : 4.87000   Max.   : 2.8400
##   gyros_arm_z       accel_arm_x       accel_arm_y      accel_arm_z
##  Min.   :-2.3300   Min.   :-404.00   Min.   :-318.0   Min.   :-636.00
##  1st Qu.:-0.0700   1st Qu.:-242.00   1st Qu.: -54.0   1st Qu.:-143.00
##  Median : 0.2300   Median : -44.00   Median :  14.0   Median : -47.00
##  Mean   : 0.2695   Mean   : -60.24   Mean   :  32.6   Mean   : -71.25
##  3rd Qu.: 0.7200   3rd Qu.:  84.00   3rd Qu.: 139.0   3rd Qu.:  23.00
##  Max.   : 3.0200   Max.   : 437.00   Max.   : 308.0   Max.   : 292.00
##   magnet_arm_x     magnet_arm_y     magnet_arm_z    roll_dumbbell
##  Min.   :-584.0   Min.   :-392.0   Min.   :-597.0   Min.   :-153.71
##  1st Qu.:-300.0   1st Qu.:  -9.0   1st Qu.: 131.2   1st Qu.: -18.49
##  Median : 289.0   Median : 202.0   Median : 444.0   Median :  48.17
##  Mean   : 191.7   Mean   : 156.6   Mean   : 306.5   Mean   :  23.84
##  3rd Qu.: 637.0   3rd Qu.: 323.0   3rd Qu.: 545.0   3rd Qu.:  67.61
##  Max.   : 782.0   Max.   : 583.0   Max.   : 694.0   Max.   : 153.55
##  pitch_dumbbell     yaw_dumbbell      total_accel_dumbbell
##  Min.   :-149.59   Min.   :-150.871   Min.   : 0.00
##  1st Qu.: -40.89   1st Qu.: -77.644   1st Qu.: 4.00
##  Median : -20.96   Median :  -3.324   Median :10.00
##  Mean   : -10.78   Mean   :   1.674   Mean   :13.72
##  3rd Qu.:  17.50   3rd Qu.:  79.643   3rd Qu.:19.00
##  Max.   : 149.40   Max.   : 154.952   Max.   :58.00
##  gyros_dumbbell_x    gyros_dumbbell_y   gyros_dumbbell_z
##  Min.   :-204.0000   Min.   :-2.10000   Min.   : -2.380
##  1st Qu.:  -0.0300   1st Qu.:-0.14000   1st Qu.: -0.310
##  Median :   0.1300   Median : 0.03000   Median : -0.130
##  Mean   :   0.1611   Mean   : 0.04606   Mean   : -0.129
##  3rd Qu.:   0.3500   3rd Qu.: 0.21000   3rd Qu.:  0.030
##  Max.   :   2.2200   Max.   :52.00000   Max.   :317.000
##  accel_dumbbell_x  accel_dumbbell_y  accel_dumbbell_z  magnet_dumbbell_x
##  Min.   :-419.00   Min.   :-189.00   Min.   :-334.00   Min.   :-643.0
##  1st Qu.: -50.00   1st Qu.:  -8.00   1st Qu.:-142.00   1st Qu.:-535.0
##  Median :  -8.00   Median :  41.50   Median :  -1.00   Median :-479.0
##  Mean   : -28.62   Mean   :  52.63   Mean   : -38.32   Mean   :-328.5
##  3rd Qu.:  11.00   3rd Qu.: 111.00   3rd Qu.:  38.00   3rd Qu.:-304.0
##  Max.   : 235.00   Max.   : 315.00   Max.   : 318.00   Max.   : 592.0
##  magnet_dumbbell_y magnet_dumbbell_z  roll_forearm       pitch_forearm
##  Min.   :-3600     Min.   :-262.00   Min.   :-180.0000   Min.   :-72.50
##  1st Qu.:  231     1st Qu.: -45.00   1st Qu.:  -0.7375   1st Qu.:  0.00
##  Median :  311     Median :  13.00   Median :  21.7000   Median :  9.24
##  Mean   :  221     Mean   :  46.05   Mean   :  33.8265   Mean   : 10.71
##  3rd Qu.:  390     3rd Qu.:  95.00   3rd Qu.: 140.0000   3rd Qu.: 28.40
```

```
##  Max.   :  633     Max.   : 452.00   Max.   : 180.0000   Max.   : 89.80
##   yaw_forearm      total_accel_forearm gyros_forearm_x
##  Min.   :-180.00   Min.   :  0.00      Min.   :-22.000
##  1st Qu.: -68.60   1st Qu.: 29.00      1st Qu.: -0.220
##  Median :   0.00   Median : 36.00      Median :  0.050
##  Mean   :  19.21   Mean   : 34.72      Mean   :  0.158
##  3rd Qu.: 110.00   3rd Qu.: 41.00      3rd Qu.:  0.560
##  Max.   : 180.00   Max.   :108.00      Max.   :  3.970
##  gyros_forearm_y     gyros_forearm_z    accel_forearm_x   accel_forearm_y
##  Min.   : -7.02000   Min.   : -8.0900   Min.   :-498.00   Min.   :-632.0
##  1st Qu.: -1.46000   1st Qu.: -0.1800   1st Qu.:-178.00   1st Qu.:  57.0
##  Median :  0.03000   Median :  0.0800   Median : -57.00   Median : 201.0
##  Mean   :  0.07517   Mean   :  0.1512   Mean   : -61.65   Mean   : 163.7
##  3rd Qu.:  1.62000   3rd Qu.:  0.4900   3rd Qu.:  76.00   3rd Qu.: 312.0
##  Max.   :311.00000   Max.   :231.0000   Max.   : 477.00   Max.   : 923.0
##  accel_forearm_z   magnet_forearm_x  magnet_forearm_y magnet_forearm_z
##  Min.   :-446.00   Min.   :-1280.0   Min.   :-896.0   Min.   :-973.0
##  1st Qu.:-182.00   1st Qu.: -616.0   1st Qu.:   2.0   1st Qu.: 191.0
##  Median : -39.00   Median : -378.0   Median : 591.0   Median : 511.0
##  Mean   : -55.29   Mean   : -312.6   Mean   : 380.1   Mean   : 393.6
##  3rd Qu.:  26.00   3rd Qu.:  -73.0   3rd Qu.: 737.0   3rd Qu.: 653.0
##  Max.   : 291.00   Max.   :  672.0   Max.   :1480.0   Max.   :1090.0
##  classe
##  A:5580
##  B:3797
##  C:3422
##  D:3216
##  E:3607
##
```

```
summary(testingdata)
```

```
##    roll_belt          pitch_belt         yaw_belt      total_accel_belt
##  Min.   : -5.9200   Min.   :-41.600   Min.   :-93.70   Min.   : 2.00
##  1st Qu.:  0.9075   1st Qu.:  3.013   1st Qu.:-88.62   1st Qu.: 3.00
##  Median :  1.1100   Median :  4.655   Median :-87.85   Median : 4.00
##  Mean   : 31.3055   Mean   :  5.824   Mean   :-59.30   Mean   : 7.55
##  3rd Qu.: 32.5050   3rd Qu.:  6.135   3rd Qu.:-63.50   3rd Qu.: 8.00
##  Max.   :129.0000   Max.   : 27.800   Max.   :162.00   Max.   :21.00
##   gyros_belt_x     gyros_belt_y     gyros_belt_z      accel_belt_x
##  Min.   :-0.500   Min.   :-0.050   Min.   :-0.4800   Min.   :-48.00
##  1st Qu.:-0.070   1st Qu.:-0.005   1st Qu.:-0.1375   1st Qu.:-19.00
##  Median : 0.020   Median : 0.000   Median :-0.0250   Median :-13.00
##  Mean   :-0.045   Mean   : 0.010   Mean   :-0.1005   Mean   :-13.50
##  3rd Qu.: 0.070   3rd Qu.: 0.020   3rd Qu.: 0.0000   3rd Qu.: -8.75
##  Max.   : 0.240   Max.   : 0.110   Max.   : 0.0500   Max.   : 46.00
##   accel_belt_y     accel_belt_z     magnet_belt_x    magnet_belt_y
##  Min.   :-16.00   Min.   :-187.00   Min.   :-13.00   Min.   :566.0
##  1st Qu.:  2.00   1st Qu.: -24.00   1st Qu.:  5.50   1st Qu.:578.5
##  Median :  4.50   Median :  27.00   Median : 33.50   Median :600.5
```

```
##  Mean   : 18.35   Mean   : -17.60   Mean   : 35.15   Mean   :601.5
##  3rd Qu.: 25.50   3rd Qu.:  38.25   3rd Qu.: 46.25   3rd Qu.:631.2
##  Max.   : 72.00   Max.   :  49.00   Max.   :169.00   Max.   :638.0
##  magnet_belt_z       roll_arm         pitch_arm          yaw_arm
##  Min.   :-426.0   Min.   :-137.00   Min.   :-63.800   Min.   :-167.00
##  1st Qu.:-398.5   1st Qu.:   0.00   1st Qu.: -9.188   1st Qu.: -60.15
##  Median :-313.5   Median :   0.00   Median :  0.000   Median :   0.00
##  Mean   :-346.9   Mean   :  16.42   Mean   : -3.950   Mean   :  -2.80
##  3rd Qu.:-305.0   3rd Qu.:  71.53   3rd Qu.:  3.465   3rd Qu.:  25.50
##  Max.   :-291.0   Max.   : 152.00   Max.   : 55.000   Max.   : 178.00
##  total_accel_arm  gyros_arm_x      gyros_arm_y       gyros_arm_z
##  Min.   : 3.00   Min.   :-3.710   Min.   :-2.0900   Min.   :-0.6900
##  1st Qu.:20.25   1st Qu.:-0.645   1st Qu.:-0.6350   1st Qu.:-0.1800
##  Median :29.50   Median : 0.020   Median :-0.0400   Median :-0.0250
##  Mean   :26.40   Mean   : 0.077   Mean   :-0.1595   Mean   : 0.1205
##  3rd Qu.:33.25   3rd Qu.: 1.248   3rd Qu.: 0.2175   3rd Qu.: 0.5650
##  Max.   :44.00   Max.   : 3.660   Max.   : 1.8500   Max.   : 1.1300
##   accel_arm_x      accel_arm_y      accel_arm_z       magnet_arm_x
##  Min.   :-341.0   Min.   :-65.00   Min.   :-404.00   Min.   :-428.00
##  1st Qu.:-277.0   1st Qu.: 52.25   1st Qu.:-128.50   1st Qu.:-373.75
##  Median :-194.5   Median :112.00   Median : -83.50   Median :-265.00
##  Mean   :-134.6   Mean   :103.10   Mean   : -87.85   Mean   : -38.95
##  3rd Qu.:   5.5   3rd Qu.:168.25   3rd Qu.: -27.25   3rd Qu.: 250.50
##  Max.   : 106.0   Max.   :245.00   Max.   :  93.00   Max.   : 750.00
##   magnet_arm_y     magnet_arm_z    roll_dumbbell      pitch_dumbbell
##  Min.   :-307.0   Min.   :-499.0   Min.   :-111.118   Min.   :-54.97
##  1st Qu.: 205.2   1st Qu.: 403.0   1st Qu.:   7.494   1st Qu.:-51.89
##  Median : 291.0   Median : 476.5   Median :  50.403   Median :-40.81
##  Mean   : 239.4   Mean   : 369.8   Mean   :  33.760   Mean   :-19.47
##  3rd Qu.: 358.8   3rd Qu.: 517.0   3rd Qu.:  58.129   3rd Qu.: 16.12
##  Max.   : 474.0   Max.   : 633.0   Max.   : 123.984   Max.   : 96.87
##   yaw_dumbbell       total_accel_dumbbell gyros_dumbbell_x
##  Min.   :-103.3200   Min.   : 1.0         Min.   :-1.0300
##  1st Qu.: -75.2809   1st Qu.: 7.0         1st Qu.: 0.1600
##  Median :  -8.2863   Median :15.5         Median : 0.3600
##  Mean   :  -0.9385   Mean   :17.2         Mean   : 0.2690
##  3rd Qu.:  55.8335   3rd Qu.:29.0         3rd Qu.: 0.4625
##  Max.   : 132.2337   Max.   :31.0         Max.   : 1.0600
##  gyros_dumbbell_y  gyros_dumbbell_z accel_dumbbell_x  accel_dumbbell_y
##  Min.   :-1.1100   Min.   :-1.180   Min.   :-159.00   Min.   :-30.00
##  1st Qu.:-0.2100   1st Qu.:-0.485   1st Qu.:-140.25   1st Qu.:  5.75
##  Median : 0.0150   Median :-0.280   Median : -19.00   Median : 71.50
##  Mean   : 0.0605   Mean   :-0.266   Mean   : -47.60   Mean   : 70.55
##  3rd Qu.: 0.1450   3rd Qu.:-0.165   3rd Qu.:  15.75   3rd Qu.:151.25
##  Max.   : 1.9100   Max.   : 1.100   Max.   : 185.00   Max.   :166.00
##  accel_dumbbell_z magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z
##  Min.   :-221.0   Min.   :-576.0    Min.   :-558.0    Min.   :-164.00
##  1st Qu.:-192.2   1st Qu.:-528.0    1st Qu.: 259.5    1st Qu.: -33.00
##  Median :  -3.0   Median :-508.5    Median : 316.0    Median :  49.50
##  Mean   : -60.0   Mean   :-304.2    Mean   : 189.3    Mean   :  71.40
```

```
##  3rd Qu.:  76.5   3rd Qu.:-317.0    3rd Qu.: 348.2    3rd Qu.:  96.25
##  Max.   : 100.0   Max.   : 523.0    Max.   : 403.0    Max.   : 368.00
##   roll_forearm     pitch_forearm      yaw_forearm
##  Min.   :-176.00   Min.   :-63.500   Min.   :-168.000
##  1st Qu.: -40.25   1st Qu.:-11.457   1st Qu.: -93.375
##  Median :  94.20   Median :  8.830   Median : -19.250
##  Mean   :  38.66   Mean   :  7.099   Mean   :   2.195
##  3rd Qu.: 143.25   3rd Qu.: 28.500   3rd Qu.: 104.500
##  Max.   : 176.00   Max.   : 59.300   Max.   : 159.000
##  total_accel_forearm gyros_forearm_x   gyros_forearm_y   gyros_forearm_z
##  Min.   :21.00       Min.   :-1.0600   Min.   :-5.9700   Min.   :-1.2600
##  1st Qu.:24.00       1st Qu.:-0.5850   1st Qu.:-1.2875   1st Qu.:-0.0975
##  Median :32.50       Median : 0.0200   Median : 0.0350   Median : 0.2300
##  Mean   :32.05       Mean   :-0.0200   Mean   :-0.0415   Mean   : 0.2610
##  3rd Qu.:36.75       3rd Qu.: 0.2925   3rd Qu.: 2.0475   3rd Qu.: 0.7625
##  Max.   :47.00       Max.   : 1.3800   Max.   : 4.2600   Max.   : 1.8000
##  accel_forearm_x  accel_forearm_y  accel_forearm_z  magnet_forearm_x
##  Min.   :-212.0   Min.   :-331.0   Min.   :-282.0   Min.   :-714.0
##  1st Qu.:-114.8   1st Qu.:   8.5   1st Qu.:-199.0   1st Qu.:-427.2
##  Median :  86.0   Median : 138.0   Median :-148.5   Median :-189.5
##  Mean   :  38.8   Mean   : 125.3   Mean   : -93.7   Mean   :-159.2
##  3rd Qu.: 166.2   3rd Qu.: 268.0   3rd Qu.: -31.0   3rd Qu.:  41.5
##  Max.   : 232.0   Max.   : 406.0   Max.   : 179.0   Max.   : 532.0
##  magnet_forearm_y magnet_forearm_z   problem_id
##  Min.   :-787.0   Min.   :-32.0    Min.   : 1.00
##  1st Qu.:-328.8   1st Qu.:275.2    1st Qu.: 5.75
##  Median : 487.0   Median :491.5    Median :10.50
##  Mean   : 191.8   Mean   :460.2    Mean   :10.50
##  3rd Qu.: 720.8   3rd Qu.:661.5    3rd Qu.:15.25
##  Max.   : 800.0   Max.   :884.0    Max.   :20.00
```

We then set up the data for it to be able to be predicted. Firstly, the data will be run using a decision tree. Followed by a randomForest analysis:

```
#plotting the decision tree"
library(rpart)
library(rpart.plot)
library(caret)
library(randomForest)
#Predicting the data set using "classe"

inTrain<-createDataPartition(y=trainingdata$classe, p = 0.75,list= FALSE)
training<- trainingdata[inTrain,]
testing <- trainingdata[-inTrain,]

#graphing training values
plot(training$classe,col="orange", main=" Classes in the Training
data",xlab="levels",ylab="Frequency")
```

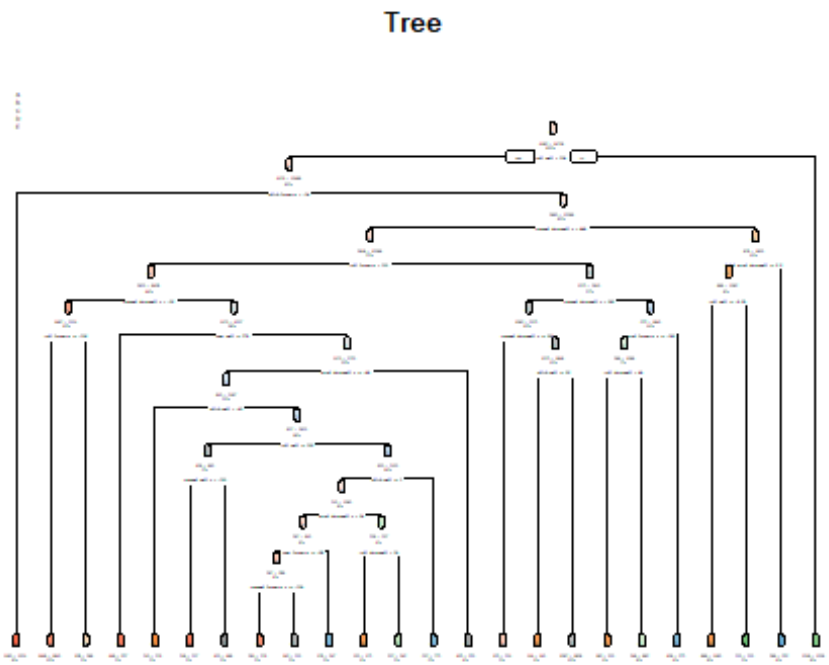

```
#Using a DecisionTree:
model1<- rpart( classe ~ .,  data= training, method = "class")

pred<- predict(model1, testing, type ="class")

confusionMatrix(pred, testing$classe)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1238  139   25   52   35
##          B   45  583   48   59   89
##          C   24   76  682  122   79
##          D   62   72   47  520   57
##          E   26   79   53   51  641
##
## Overall Statistics
##
##                Accuracy : 0.7471
##                  95% CI : (0.7347, 0.7593)
##     No Information Rate : 0.2845
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.6795
##  Mcnemar's Test P-Value : < 2.2e-16
##
```

```
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.8875   0.6143   0.7977   0.6468   0.7114
## Specificity            0.9285   0.9391   0.9257   0.9420   0.9478
## Pos Pred Value         0.8314   0.7075   0.6938   0.6860   0.7541
## Neg Pred Value         0.9540   0.9103   0.9559   0.9315   0.9359
## Prevalence             0.2845   0.1935   0.1743   0.1639   0.1837
## Detection Rate         0.2524   0.1189   0.1391   0.1060   0.1307
## Detection Prevalence   0.3036   0.1680   0.2004   0.1546   0.1733
## Balanced Accuracy      0.9080   0.7767   0.8617   0.7944   0.8296
```

```
#DecisionTree PLot
rpart.plot(model1,main="Tree",extra=102, under=TRUE,faclen=0)
```

```
## Warning: labs do not fit even at cex 0.15, there may be some overplotting
```



Above, we looked at the data using a Decision Tree to predit the values for A-E. One figure to note is the low accuracy rate hovering around 65%. Now, we look at a different way to conduct the prediction that involves the use of a random Forest tree

```
model1<- rpart( classe ~ .,  data= training, method = "class")

pred<- predict(model1, testing, type ="class")

confusionMatrix(pred, testing$classe)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1238  139   25   52   35
##          B   45  583   48   59   89
##          C   24   76  682  122   79
##          D   62   72   47  520   57
##          E   26   79   53   51  641
##
## Overall Statistics
##
##                Accuracy : 0.7471
##                  95% CI : (0.7347, 0.7593)
##     No Information Rate : 0.2845
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.6795
##  Mcnemar's Test P-Value : < 2.2e-16
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.8875   0.6143   0.7977   0.6468   0.7114
## Specificity            0.9285   0.9391   0.9257   0.9420   0.9478
## Pos Pred Value         0.8314   0.7075   0.6938   0.6860   0.7541
## Neg Pred Value         0.9540   0.9103   0.9559   0.9315   0.9359
## Prevalence             0.2845   0.1935   0.1743   0.1639   0.1837
## Detection Rate         0.2524   0.1189   0.1391   0.1060   0.1307
## Detection Prevalence   0.3036   0.1680   0.2004   0.1546   0.1733
## Balanced Accuracy      0.9080   0.7767   0.8617   0.7944   0.8296
```

Conclusion:

Overall, the random Forestis much more accurate at predicting the values. Its accuracy rate is > 99%. So, in my opinion it is much better to use a random forest as it is the most accurate prediction model.