# Prediction Assignment Writeup

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# Summary of 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://web.archive.org/web/20161224072740/http:/groupware.les.inf.puc-rio.br/har (http://web.archive.org/web/20161224072740/http:/groupware.les.inf.puc-rio.br/har) (see the section on the Weight Lifting Exercise Dataset).

# Load library

```
library(data.table)
library(ggplot2)
library(caret)
```

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

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:data.table':
##
##     between, first, last
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(rpart)
library(gbm)
```

```
## Loaded gbm 2.1.5
```

```
library(randomForest)
```

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

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

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

```
## The following object is masked from 'package:dplyr':
##
##     combine
```

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

# Load data

```
data_train <- read.csv("/Users/siying/Downloads/pml-training.csv")
data_test <- read.csv("/Users/siying/Downloads/pml-testing.csv")
dim(data_train)
```

```
## [1] 19622   160
```

```
dim(data_test)
```

```
## [1]  20 160
```

```
summary(data_train$classe)
```

```
##    A    B    C    D    E
## 5580 3797 3422 3216 3607
```

# Dataset partition for training data

```
data_train_part <- createDataPartition(data_train$classe, p=0.7, list=FALSE)
data_train_train <- data_train[data_train_part, ]
data_train_test <- data_train[-data_train_part, ]
dim(data_train_train)
```

```
## [1] 13737   160
```

```
dim(data_train_test)
```

```
## [1] 5885  160
```

# Remove useless variable for identification

```
data_train_train <- data_train_train[, -c(1:5)]
data_train_test  <- data_train_test[, -c(1:5)]
data_test  <- data_test[, -c(1:5)]
```

# Near zero variance elimination

```
col_nzv <- nearZeroVar(data_train_train)
data_train_train <- data_train_train[, -col_nzv]
data_train_test  <- data_train_test[, -col_nzv]
data_test <- data_test[, -col_nzv]
dim(data_train_train)
```

```
## [1] 13737   100
```

```
dim(data_train_test)
```

```
## [1] 5885  100
```

```
dim(data_test)
```

```
## [1]  20 100
```

# Remove NA variable (include almost NA)

```
col_na  <- sapply(data_train_train, function(x) mean(is.na(x))) >0.9
data_train_train <- data_train_train[, col_na==FALSE]
data_train_test  <- data_train_test[, col_na==FALSE]
data_test <- data_test[, col_na==FALSE]
dim(data_train_train)
```

```
## [1] 13737    54
```

```
dim(data_train_test)
```

```
## [1] 5885   54
```

```
dim(data_test)
```

```
## [1] 20 54
```

```
summary(data_train_train)
```

```
##    num_window      roll_belt        pitch_belt          yaw_belt
##  Min.   :  1.0   Min.   :-28.80   Min.   :-55.8000   Min.   :-180.00
##  1st Qu.:223.0   1st Qu.:  1.09   1st Qu.:  1.7900   1st Qu.: -88.30
##  Median :425.0   Median :113.00   Median :  5.2800   Median : -14.30
##  Mean   :430.9   Mean   : 64.01   Mean   :  0.3697   Mean   : -11.75
##  3rd Qu.:645.0   3rd Qu.:123.00   3rd Qu.: 14.9000   3rd Qu.:   8.66
##  Max.   :864.0   Max.   :162.00   Max.   : 60.3000   Max.   : 179.00
##  total_accel_belt  gyros_belt_x        gyros_belt_y       gyros_belt_z
##  Min.   : 0.00    Min.   :-1.040000   Min.   :-0.53000   Min.   :-1.330
##  1st Qu.: 3.00    1st Qu.:-0.030000   1st Qu.: 0.00000   1st Qu.:-0.200
##  Median :17.00    Median : 0.030000   Median : 0.02000   Median :-0.100
##  Mean   :11.27    Mean   :-0.005739   Mean   : 0.03873   Mean   :-0.132
##  3rd Qu.:18.00    3rd Qu.: 0.110000   3rd Qu.: 0.11000   3rd Qu.:-0.020
##  Max.   :28.00    Max.   : 2.220000   Max.   : 0.64000   Max.   : 1.610
##   accel_belt_x       accel_belt_y     accel_belt_z     magnet_belt_x
##  Min.   :-120.000   Min.   :-65.00   Min.   :-269.00   Min.   :-52.00
##  1st Qu.: -21.000   1st Qu.:  3.00   1st Qu.:-162.00   1st Qu.:  9.00
##  Median : -15.000   Median : 32.00   Median :-150.00   Median : 35.00
##  Mean   :  -5.719   Mean   : 29.98   Mean   : -71.87   Mean   : 55.22
##  3rd Qu.:  -5.000   3rd Qu.: 61.00   3rd Qu.:  28.00   3rd Qu.: 59.00
##  Max.   :  79.000   Max.   :164.00   Max.   : 103.00   Max.   :485.00
##  magnet_belt_y   magnet_belt_z     roll_arm         pitch_arm
##  Min.   :354.0   Min.   :-621   Min.   :-180.00   Min.   :-88.800
```

```
##  1st Qu.:582.0   1st Qu.:-374   1st Qu.: -30.90   1st Qu.:-25.800
##  Median :601.0   Median :-319   Median :   0.00   Median :  0.000
##  Mean   :594.1   Mean   :-345   Mean   :  18.21   Mean   : -4.726
##  3rd Qu.:610.0   3rd Qu.:-306   3rd Qu.:  77.40   3rd Qu.: 11.100
##  Max.   :669.0   Max.   : 289   Max.   : 180.00   Max.   : 88.200
##     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.: -42.2000   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   :  -0.4126   Mean   :25.48   Mean   : 0.05367   Mean   :-0.2596
##  3rd Qu.:  45.8000   3rd Qu.:33.00   3rd Qu.: 1.59000   3rd Qu.: 0.1600
##  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.   :-383.00   Min.   :-318.0   Min.   :-636.00
##  1st Qu.:-0.0800   1st Qu.:-241.00   1st Qu.: -53.0   1st Qu.:-144.00
##  Median : 0.2300   Median : -44.00   Median :  15.0   Median : -46.00
##  Mean   : 0.2664   Mean   : -60.33   Mean   :  33.5   Mean   : -70.85
##  3rd Qu.: 0.7200   3rd Qu.:  83.00   3rd Qu.: 141.0   3rd Qu.:  23.00
##  Max.   : 2.9500   Max.   : 435.00   Max.   : 303.0   Max.   : 292.00
##   magnet_arm_x     magnet_arm_y     magnet_arm_z    roll_dumbbell
##  Min.   :-584.0   Min.   :-377.0   Min.   :-595.0   Min.   :-153.71
##  1st Qu.:-297.0   1st Qu.:  -7.0   1st Qu.: 137.0   1st Qu.: -17.59
##  Median : 291.0   Median : 202.0   Median : 444.0   Median :  48.28
##  Mean   : 192.7   Mean   : 157.4   Mean   : 308.1   Mean   :  24.24
##  3rd Qu.: 636.0   3rd Qu.: 323.0   3rd Qu.: 545.0   3rd Qu.:  67.99
##  Max.   : 782.0   Max.   : 583.0   Max.   : 694.0   Max.   : 153.55
##  pitch_dumbbell     yaw_dumbbell      total_accel_dumbbell
##  Min.   :-148.50   Min.   :-150.871   Min.   : 0.00
##  1st Qu.: -40.94   1st Qu.: -77.579   1st Qu.: 4.00
##  Median : -21.02   Median :  -3.191   Median :11.00
##  Mean   : -10.77   Mean   :   1.609   Mean   :13.79
##  3rd Qu.:  17.58   3rd Qu.:  79.385   3rd Qu.:20.00
##  Max.   : 149.40   Max.   : 154.952   Max.   :42.00
##  gyros_dumbbell_x  gyros_dumbbell_y   gyros_dumbbell_z  accel_dumbbell_x
##  Min.   :-1.8500   Min.   :-2.10000   Min.   :-2.3800   Min.   :-237.00
##  1st Qu.:-0.0300   1st Qu.:-0.14000   1st Qu.:-0.3100   1st Qu.: -51.00
##  Median : 0.1400   Median : 0.03000   Median :-0.1300   Median :  -8.00
##  Mean   : 0.1725   Mean   : 0.04269   Mean   :-0.1446   Mean   : -28.71
##  3rd Qu.: 0.3500   3rd Qu.: 0.21000   3rd Qu.: 0.0300   3rd Qu.:  11.00
##  Max.   : 2.2000   Max.   : 4.37000   Max.   : 1.8700   Max.   : 235.00
##  accel_dumbbell_y  accel_dumbbell_z  magnet_dumbbell_x magnet_dumbbell_y
##  Min.   :-182.00   Min.   :-334.00   Min.   :-639.0    Min.   :-3600
##  1st Qu.:  -8.00   1st Qu.:-142.00   1st Qu.:-535.0    1st Qu.:  233
##  Median :  43.00   Median :  -1.00   Median :-479.0    Median :  311
##  Mean   :  53.37   Mean   : -38.73   Mean   :-327.4    Mean   :  222
##  3rd Qu.: 114.00   3rd Qu.:  38.00   3rd Qu.:-297.0    3rd Qu.:  391
##  Max.   : 302.00   Max.   : 318.00   Max.   : 592.0    Max.   :  633
##  magnet_dumbbell_z  roll_forearm     pitch_forearm     yaw_forearm
##  Min.   :-250.00   Min.   :-180.00   Min.   :-72.50   Min.   :-180.00
##  1st Qu.: -45.00   1st Qu.:  -0.68   1st Qu.:  0.00   1st Qu.: -68.10
```

```
##  Median :  14.00   Median :  22.60   Median :  9.23   Median :   0.00
##  Mean   :  46.15   Mean   :  34.39   Mean   : 10.69   Mean   :  20.24
##  3rd Qu.:  96.00   3rd Qu.: 140.00   3rd Qu.: 28.50   3rd Qu.: 110.00
##  Max.   : 451.00   Max.   : 180.00   Max.   : 89.80   Max.   : 180.00
##  total_accel_forearm gyros_forearm_x   gyros_forearm_y
##  Min.   : 0.00       Min.   :-2.9900   Min.   :-6.65000
##  1st Qu.:29.00       1st Qu.:-0.2200   1st Qu.:-1.46000
##  Median :36.00       Median : 0.0500   Median : 0.03000
##  Mean   :34.71       Mean   : 0.1542   Mean   : 0.06953
##  3rd Qu.:41.00       3rd Qu.: 0.5600   3rd Qu.: 1.62000
##  Max.   :78.00       Max.   : 3.9700   Max.   : 6.13000
##  gyros_forearm_z   accel_forearm_x   accel_forearm_y  accel_forearm_z
##  Min.   :-8.0900   Min.   :-498.00   Min.   :-632.0   Min.   :-410.00
##  1st Qu.:-0.1800   1st Qu.:-178.00   1st Qu.:  53.0   1st Qu.:-182.00
##  Median : 0.0800   Median : -57.00   Median : 199.0   Median : -43.00
##  Mean   : 0.1401   Mean   : -61.71   Mean   : 161.9   Mean   : -56.58
##  3rd Qu.: 0.4900   3rd Qu.:  77.00   3rd Qu.: 311.0   3rd Qu.:  26.00
##  Max.   : 4.3100   Max.   : 389.00   Max.   : 591.0   Max.   : 275.00
##  magnet_forearm_x  magnet_forearm_y magnet_forearm_z classe
##  Min.   :-1280.0   Min.   :-892     Min.   :-966.0   A:3906
##  1st Qu.: -615.0   1st Qu.:  -3     1st Qu.: 192.0   B:2658
##  Median : -377.0   Median : 583     Median : 513.0   C:2396
##  Mean   : -311.8   Mean   : 375     Mean   : 395.8   D:2252
##  3rd Qu.:  -74.0   3rd Qu.: 736     3rd Qu.: 653.0   E:2525
##  Max.   :  672.0   Max.   :1480     Max.   :1090.0
```

```
summary(data_test)
```

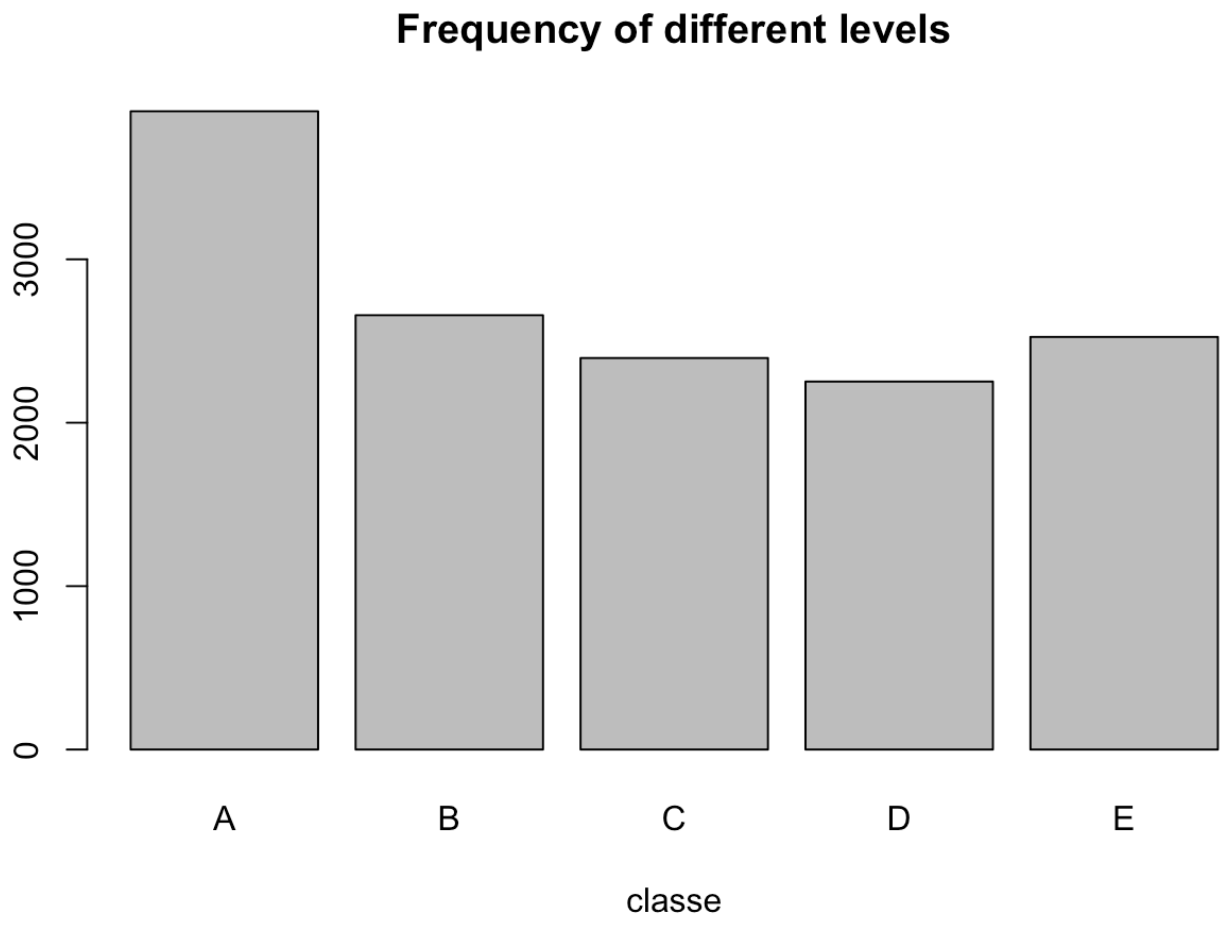
```
##    num_window      roll_belt         pitch_belt        yaw_belt
##  Min.   : 48.0   Min.   : -5.9200   Min.   :-41.600   Min.   :-93.70
##  1st Qu.:250.0   1st Qu.:  0.9075   1st Qu.:  3.013   1st Qu.:-88.62
##  Median :384.5   Median :  1.1100   Median :  4.655   Median :-87.85
##  Mean   :379.6   Mean   : 31.3055   Mean   :  5.824   Mean   :-59.30
##  3rd Qu.:467.0   3rd Qu.: 32.5050   3rd Qu.:  6.135   3rd Qu.:-63.50
##  Max.   :859.0   Max.   :129.0000   Max.   : 27.800   Max.   :162.00
##  total_accel_belt  gyros_belt_x     gyros_belt_y     gyros_belt_z
##  Min.   : 2.00    Min.   :-0.500   Min.   :-0.050   Min.   :-0.4800
##  1st Qu.: 3.00    1st Qu.:-0.070   1st Qu.:-0.005   1st Qu.:-0.1375
##  Median : 4.00    Median : 0.020   Median : 0.000   Median :-0.0250
##  Mean   : 7.55    Mean   :-0.045   Mean   : 0.010   Mean   :-0.1005
##  3rd Qu.: 8.00    3rd Qu.: 0.070   3rd Qu.: 0.020   3rd Qu.: 0.0000
##  Max.   :21.00    Max.   : 0.240   Max.   : 0.110   Max.   : 0.0500
##   accel_belt_x     accel_belt_y     accel_belt_z     magnet_belt_x
##  Min.   :-48.00   Min.   :-16.00   Min.   :-187.00   Min.   :-13.00
##  1st Qu.:-19.00   1st Qu.:  2.00   1st Qu.: -24.00   1st Qu.:  5.50
##  Median :-13.00   Median :  4.50   Median :  27.00   Median : 33.50
##  Mean   :-13.50   Mean   : 18.35   Mean   : -17.60   Mean   : 35.15
##  3rd Qu.: -8.75   3rd Qu.: 25.50   3rd Qu.:  38.25   3rd Qu.: 46.25
##  Max.   : 46.00   Max.   : 72.00   Max.   :  49.00   Max.   :169.00
```

```
##  magnet_belt_y   magnet_belt_z       roll_arm         pitch_arm
##  Min.   :566.0   Min.   :-426.0   Min.   :-137.00   Min.   :-63.800
##  1st Qu.:578.5   1st Qu.:-398.5   1st Qu.:   0.00   1st Qu.: -9.188
##  Median :600.5   Median :-313.5   Median :   0.00   Median :  0.000
##  Mean   :601.5   Mean   :-346.9   Mean   :  16.42   Mean   : -3.950
##  3rd Qu.:631.2   3rd Qu.:-305.0   3rd Qu.:  71.53   3rd Qu.:  3.465
##  Max.   :638.0   Max.   :-291.0   Max.   : 152.00   Max.   : 55.000
##     yaw_arm        total_accel_arm  gyros_arm_x      gyros_arm_y
##  Min.   :-167.00   Min.   : 3.00   Min.   :-3.710   Min.   :-2.0900
##  1st Qu.: -60.15   1st Qu.:20.25   1st Qu.:-0.645   1st Qu.:-0.6350
##  Median :   0.00   Median :29.50   Median : 0.020   Median :-0.0400
##  Mean   :  -2.80   Mean   :26.40   Mean   : 0.077   Mean   :-0.1595
##  3rd Qu.:  25.50   3rd Qu.:33.25   3rd Qu.: 1.248   3rd Qu.: 0.2175
##  Max.   : 178.00   Max.   :44.00   Max.   : 3.660   Max.   : 1.8500
##   gyros_arm_z       accel_arm_x      accel_arm_y      accel_arm_z
##  Min.   :-0.6900   Min.   :-341.0   Min.   :-65.00   Min.   :-404.00
##  1st Qu.:-0.1800   1st Qu.:-277.0   1st Qu.: 52.25   1st Qu.:-128.50
##  Median :-0.0250   Median :-194.5   Median :112.00   Median : -83.50
##  Mean   : 0.1205   Mean   :-134.6   Mean   :103.10   Mean   : -87.85
##  3rd Qu.: 0.5650   3rd Qu.:   5.5   3rd Qu.:168.25   3rd Qu.: -27.25
##  Max.   : 1.1300   Max.   : 106.0   Max.   :245.00   Max.   :  93.00
##   magnet_arm_x      magnet_arm_y     magnet_arm_z    roll_dumbbell
##  Min.   :-428.00   Min.   :-307.0   Min.   :-499.0   Min.   :-111.118
##  1st Qu.:-373.75   1st Qu.: 205.2   1st Qu.: 403.0   1st Qu.:   7.494
##  Median :-265.00   Median : 291.0   Median : 476.5   Median :  50.403
##  Mean   : -38.95   Mean   : 239.4   Mean   : 369.8   Mean   :  33.760
##  3rd Qu.: 250.50   3rd Qu.: 358.8   3rd Qu.: 517.0   3rd Qu.:  58.129
##  Max.   : 750.00   Max.   : 474.0   Max.   : 633.0   Max.   : 123.984
##  pitch_dumbbell    yaw_dumbbell       total_accel_dumbbell
##  Min.   :-54.97   Min.   :-103.3200   Min.   : 1.0
##  1st Qu.:-51.89   1st Qu.: -75.2809   1st Qu.: 7.0
##  Median :-40.81   Median :  -8.2863   Median :15.5
##  Mean   :-19.47   Mean   :  -0.9385   Mean   :17.2
##  3rd Qu.: 16.12   3rd Qu.:  55.8335   3rd Qu.:29.0
##  Max.   : 96.87   Max.   : 132.2337   Max.   :31.0
##  gyros_dumbbell_x  gyros_dumbbell_y  gyros_dumbbell_z accel_dumbbell_x
##  Min.   :-1.0300   Min.   :-1.1100   Min.   :-1.180   Min.   :-159.00
##  1st Qu.: 0.1600   1st Qu.:-0.2100   1st Qu.:-0.485   1st Qu.:-140.25
##  Median : 0.3600   Median : 0.0150   Median :-0.280   Median : -19.00
##  Mean   : 0.2690   Mean   : 0.0605   Mean   :-0.266   Mean   : -47.60
##  3rd Qu.: 0.4625   3rd Qu.: 0.1450   3rd Qu.:-0.165   3rd Qu.:  15.75
##  Max.   : 1.0600   Max.   : 1.9100   Max.   : 1.100   Max.   : 185.00
##  accel_dumbbell_y accel_dumbbell_z magnet_dumbbell_x magnet_dumbbell_y
##  Min.   :-30.00   Min.   :-221.0   Min.   :-576.0    Min.   :-558.0
##  1st Qu.:  5.75   1st Qu.:-192.2   1st Qu.:-528.0    1st Qu.: 259.5
##  Median : 71.50   Median :  -3.0   Median :-508.5    Median : 316.0
##  Mean   : 70.55   Mean   : -60.0   Mean   :-304.2    Mean   : 189.3
##  3rd Qu.:151.25   3rd Qu.:  76.5   3rd Qu.:-317.0    3rd Qu.: 348.2
##  Max.   :166.00   Max.   : 100.0   Max.   : 523.0    Max.   : 403.0
##  magnet_dumbbell_z  roll_forearm     pitch_forearm      yaw_forearm
```

```
##  Min.   :-164.00   Min.   :-176.00   Min.   :-63.500   Min.   :-168.000
##  1st Qu.: -33.00   1st Qu.: -40.25   1st Qu.:-11.457   1st Qu.: -93.375
##  Median :  49.50   Median :  94.20   Median :  8.830   Median : -19.250
##  Mean   :  71.40   Mean   :  38.66   Mean   :  7.099   Mean   :   2.195
##  3rd Qu.:  96.25   3rd Qu.: 143.25   3rd Qu.: 28.500   3rd Qu.: 104.500
##  Max.   : 368.00   Max.   : 176.00   Max.   : 59.300   Max.   : 159.000
##  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
```

##Frequency plot

```
plot(data_train_train$classe, main="Frequency of different levels", xlab="classe")
```




# Prediction models

## 1. Decision tree

```
# Fitting model
model_tree <- randomForest(classe ~., data=data_train_train, method="rpart")

# Predicting
predict_tree <- predict(model_tree, data_train_test, Type="rpart")

# Testing
confusionMatrix(predict_tree, data_train_test$classe)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1673    3    0    0    0
##          B    1 1136    2    0    0
##          C    0    0 1021    6    0
##          D    0    0    3  958    1
##          E    0    0    0    0 1081
##
## Overall Statistics
##
##                Accuracy : 0.9973
##                  95% CI : (0.9956, 0.9984)
##     No Information Rate : 0.2845
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.9966
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.9994   0.9974   0.9951   0.9938   0.9991
## Specificity            0.9993   0.9994   0.9988   0.9992   1.0000
## Pos Pred Value         0.9982   0.9974   0.9942   0.9958   1.0000
## Neg Pred Value         0.9998   0.9994   0.9990   0.9988   0.9998
## Prevalence             0.2845   0.1935   0.1743   0.1638   0.1839
## Detection Rate         0.2843   0.1930   0.1735   0.1628   0.1837
## Detection Prevalence   0.2848   0.1935   0.1745   0.1635   0.1837
## Balanced Accuracy      0.9993   0.9984   0.9969   0.9965   0.9995
```

# 2. Boosting (gradient boosting)

```
# Fitting model
Control <- trainControl(method="repeatedcv", number=5, repeats=1)
model_rf <- randomForest(classe ~., data=data_train_train, method="gbm",trControl=
Control, verbose=FALSE)

# Predicting
predict_rf <- predict(model_rf, data_train_test, Type="gbm")

# Testing
confusionMatrix(predict_rf, data_train_test$classe)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1674    3    0    0    0
##          B    0 1136    2    0    0
##          C    0    0 1021    6    0
##          D    0    0    3  958    1
##          E    0    0    0    0 1081
##
## Overall Statistics
##
##                Accuracy : 0.9975
##                  95% CI : (0.9958, 0.9986)
##     No Information Rate : 0.2845
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.9968
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            1.0000   0.9974   0.9951   0.9938   0.9991
## Specificity            0.9993   0.9996   0.9988   0.9992   1.0000
## Pos Pred Value         0.9982   0.9982   0.9942   0.9958   1.0000
## Neg Pred Value         1.0000   0.9994   0.9990   0.9988   0.9998
## Prevalence             0.2845   0.1935   0.1743   0.1638   0.1839
## Detection Rate         0.2845   0.1930   0.1735   0.1628   0.1837
## Detection Prevalence   0.2850   0.1934   0.1745   0.1635   0.1837
## Balanced Accuracy      0.9996   0.9985   0.9969   0.9965   0.9995
```

# 3. Random forest

```
# Fitting model
model_rf <- randomForest(classe ~., data=data_train_train, method="class")

# Predicting
predict_rf <- predict(model_rf, data_train_test, Type="class")

# Testing
confusionMatrix(predict_rf, data_train_test$classe)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1674    3    0    0    0
##          B    0 1136    1    0    0
##          C    0    0 1022    6    0
##          D    0    0    3  958    1
##          E    0    0    0    0 1081
##
## Overall Statistics
##
##                Accuracy : 0.9976
##                  95% CI : (0.996, 0.9987)
##     No Information Rate : 0.2845
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.997
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            1.0000   0.9974   0.9961   0.9938   0.9991
## Specificity            0.9993   0.9998   0.9988   0.9992   1.0000
## Pos Pred Value         0.9982   0.9991   0.9942   0.9958   1.0000
## Neg Pred Value         1.0000   0.9994   0.9992   0.9988   0.9998
## Prevalence             0.2845   0.1935   0.1743   0.1638   0.1839
## Detection Rate         0.2845   0.1930   0.1737   0.1628   0.1837
## Detection Prevalence   0.2850   0.1932   0.1747   0.1635   0.1837
## Balanced Accuracy      0.9996   0.9986   0.9974   0.9965   0.9995
```

# Apply to 20 test data

```
predict_test <- predict(model_rf, data_test)
predict_test
```

```
##  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20
##  B  A  B  A  A  E  D  B  A  A  B  C  B  A  E  E  A  B  B  B
## Levels: A B C D E
```