

Human Activity Recognition

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Introduction

Human Activity Recognition (HAR) has emerged as a key research area in the last years and is gaining increasing attention by the pervasive computing research community (see picture below, that illustrates the increasing number of publications in HAR with wearable accelerometers), especially for the development of context-aware systems. There are many potential applications for HAR, like: elderly monitoring, life log systems for monitoring energy expenditure and for supporting weight-loss programs, and digital assistants for weight lifting exercises. According to [1] it is possible to detect mistakes by classification in HAR data set. Customized application of this dataset can be seen in [2]. The goal of this project is to predict the manner in which the subjects exercised.

Metodology

In this project we made use of the Human Activity Recognition dataset [3] and select the following variables: classe, accel_belt_x, accel_belt_y, accel_belt_z, accel_forearm_x, accel_forearm_y, accel_forearm_z, accel_arm_x, accel_arm_y, accel_arm_z, accel_dumbbell_x, accel_dumbbell_y and accel_dumbbell_z, which are collected in six subjects. We use the R program language [4] to run the statistics analyze. The original dataset was divided in two other data sets, one for validation and the other to training. We use the Random Forest algorithm to prediction because it is usually one of the two top performing algorithms along with boosting in prediction contests.

Load packages and Set the work directory

```
## Loading required package: lattice
## Loading required package: ggplot2
## Warning: package 'ggplot2' was built under R version 4.0.3
## Warning: package 'kernlab' was built under R version 4.0.3
##
## Attaching package: 'kernlab'
## The following object is masked from 'package:ggplot2':
##
##      alpha
## Warning: package 'FactoMineR' was built under R version 4.0.5
## Warning: package 'randomForest' was built under R version 4.0.5
## randomForest 4.6-14
## Type rfNews() to see new features/changes/bug fixes.
##
## Attaching package: 'randomForest'
```

```
## The following object is masked from 'package:ggplot2':
##
##     margin
## Warning: package 'dplyr' was built under R version 4.0.5
##
## Attaching package: 'dplyr'
## The following object is masked from 'package:randomForest':
##
##     combine
## The following objects are masked from 'package:stats':
##
##     filter, lag
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
## Warning: package 'tidyr' was built under R version 4.0.3
```

Load the data set

Processing Data Set and Results

```
## Convert user_name and classe variables to factors
training$user_name <- factor(training$user_name)

## Split the data set into a 60% training and 40% probing data set
set.seed(32031)
inTrain <- createDataPartition(
  y = training$classe, p = 0.6, list = FALSE
)

trainingSample <- training[inTrain, ]

## Set the validation data set
test <- training[-inTrain, ]

## Subset the 'training' data set
test <- test %>% select(
  user_name, classe,
  accel_belt_x, accel_belt_y, accel_belt_z,
  accel_forearm_x, accel_forearm_y, accel_forearm_z,
  accel_arm_x, accel_arm_y, accel_arm_z,
  accel_dumbbell_x, accel_dumbbell_y, accel_dumbbell_z
)
test$classe <- factor(test$classe)
test$user_name <- factor(test$user_name)

trainingSample <- trainingSample %>% select(
  user_name, classe,
  accel_belt_x, accel_belt_y, accel_belt_z,
  accel_forearm_x, accel_forearm_y, accel_forearm_z,
  accel_arm_x, accel_arm_y, accel_arm_z,
```

```

        accel_dumbbell_x, accel_dumbbell_y, accel_dumbbell_z
    )

## Convert user_name and classe variables to factors
trainingSample$classe <- factor(trainingSample$classe)

```

The summary statistics for training data set and test dataset are shown below.

```

## Summary statistics
summary(trainingSample)

```

```

##           X           user_name raw_timestamp_part_1 raw_timestamp_part_2 cvtd_timestamp      new_w
## Min.      :    2      adelmo :2336      Min.      :1.322e+09      Min.      :   301      Length:11776      Length
## 1st Qu.: 4897      carlitos:1867      1st Qu.:1.323e+09      1st Qu.:254675      Class :character      Class
## Median : 9819      charles :2109      Median :1.323e+09      Median :500345      Mode  :character      Mode
## Mean    : 9814      eurico  :1795      Mean    :1.323e+09      Mean    :502106
## 3rd Qu.:14701      jeremy :2044      3rd Qu.:1.323e+09      3rd Qu.:753526
## Max.    :19622      pedro  :1625      Max.    :1.323e+09      Max.    :998749
## roll_belt      pitch_belt      yaw_belt      total_accel_belt kurtosis_roll_belt kurtosis_p
## Min.      :-28.60      Min.      :-55.800      Min.      :-180.00      Min.      : 0.00      Length:11776      Length:117
## 1st Qu.:  1.10      1st Qu.:  1.730      1st Qu.: -88.30      1st Qu.:  3.00      Class :character      Class :cha
## Median :114.00      Median :  5.310      Median : -12.00      Median :17.00      Mode  :character      Mode  :cha
## Mean    : 64.87      Mean    :  0.386      Mean    : -10.94      Mean    :11.38
## 3rd Qu.:123.00      3rd Qu.: 15.400      3rd Qu.:  13.10      3rd Qu.:18.00
## Max.    :162.00      Max.    : 60.300      Max.    : 179.00      Max.    :29.00
## skewness_roll_belt skewness_roll_belt.1 skewness_yaw_belt      max_roll_belt      max_pict_h_belt      max_ya
## Length:11776      Length:11776      Length:11776      Min.      :-94.300      Min.      : 3.00      Length
## Class :character      Class :character      Class :character      1st Qu.: -88.050      1st Qu.:  5.00      Class
## Mode  :character      Mode  :character      Mode  :character      Median : -5.900      Median :18.00      Mode
##                               Mean    : -9.026      Mean    :12.77
##                               3rd Qu.: 15.200      3rd Qu.:19.00
##                               Max.    :177.000      Max.    :30.00
## min_pitch_belt min_yaw_belt      amplitude_roll_belt amplitude_pitch_belt amplitude_yaw_belt var_
## Min.      : 0.00      Length:11776      Min.      : 0.00      Min.      : 0.000      Length:11776      Min.
## 1st Qu.:  3.00      Class :character      1st Qu.:  0.30      1st Qu.:  1.000      Class :character      1st
## Median :16.00      Mode  :character      Median :  1.00      Median :  1.000      Mode  :character      Media
## Mean    :10.65
## 3rd Qu.:17.00
## Max.    :23.00
## Max.    :27.86      Max.    :10.000
## stddev_roll_belt var_roll_belt      avg_pitch_belt      stddev_pitch_belt var_pitch_belt      avg_yaw_belt
## Min.      : 0.000      Min.      :  0.000      Min.      :-45.30      Min.      :0.000      Min.      :0.000      Min.      :-94.4
## 1st Qu.:  0.200      1st Qu.:  0.000      1st Qu.:  2.25      1st Qu.:0.200      1st Qu.:0.000      1st Qu.: -88.2
## Median :  0.400      Median :  0.100      Median :  5.00      Median :0.300      Median :0.100      Median : -6.9
## Mean    :  1.304      Mean    :  7.108      Mean    :  1.18      Mean    :0.584      Mean    :0.693      Mean    : -10.0
## 3rd Qu.:  0.700      3rd Qu.:  0.500      3rd Qu.: 15.95      3rd Qu.:0.700      3rd Qu.:0.500      3rd Qu.: 13.8
## Max.    :13.300      Max.    :177.200      Max.    : 59.70      Max.    :3.100      Max.    :9.500      Max.    :173.4
## var_yaw_belt      gyros_belt_x      gyros_belt_y      gyros_belt_z      accel_belt_x      accel_l
## Min.      : 0.000      Min.      :-1.040000      Min.      :-0.64000      Min.      :-1.4600      Min.      :-83.000      Min.
## 1st Qu.:  0.010      1st Qu.: -0.050000      1st Qu.:  0.00000      1st Qu.: -0.2000      1st Qu.: -21.000      1st Qu.
## Median :  0.089      Median :  0.030000      Median :  0.02000      Median : -0.1100      Median : -15.000      Median
## Mean    :  1.601      Mean    : -0.008505      Mean    :  0.03948      Mean    : -0.1314      Mean    : -5.774      Mean
## 3rd Qu.:  0.365      3rd Qu.:  0.110000      3rd Qu.:  0.11000      3rd Qu.: -0.0200      3rd Qu.: -5.000      3rd Qu.
## Max.    :75.920      Max.    :  2.200000      Max.    :  0.64000      Max.    :  1.6100      Max.    : 83.000      Max.
## magnet_belt_x      magnet_belt_y      magnet_belt_z      roll_arm      pitch_arm      yaw_arm
## Min.      : -52.00      Min.      :359.0      Min.      : -623.0      Min.      : -180.00      Min.      : -88.800      Min.      : -180.

```

```

## 1st Qu.: 9.00      1st Qu.:582.0    1st Qu.: -375.0    1st Qu.: -31.60    1st Qu.: -26.300    1st Qu.: -43.0
## Median : 34.00    Median :601.0    Median : -319.0    Median : 0.00      Median : 0.000      Median : 0.0
## Mean : 55.34      Mean :593.8      Mean : -345.6      Mean : 17.32      Mean : -4.816      Mean : -0.9
## 3rd Qu.: 59.00    3rd Qu.:610.0    3rd Qu.: -306.0    3rd Qu.: 77.10     3rd Qu.: 10.900     3rd Qu.: 44.4
## Max. :485.00      Max. :673.0      Max. : 289.0      Max. : 180.00      Max. : 88.500      Max. : 180.0
## var_accel_arm      avg_roll_arm      stddev_roll_arm    var_roll_arm      avg_pitch_arm      stddev_pi
## Min. : 0.00      Min. : -166.67    Min. : 0.00      Min. : 0.000      Min. : -77.019     Min. : 0
## 1st Qu.: 11.80    1st Qu.: -37.98    1st Qu.: 1.19     1st Qu.: 1.418     1st Qu.: -25.385    1st Qu.:
## Median : 40.69     Median : 0.00      Median : 6.04      Median : 36.480     Median : -2.361     Median :
## Mean : 53.04      Mean : 11.25      Mean : 11.25      Mean : 412.250     Mean : -6.819      Mean :1
## 3rd Qu.: 76.78     3rd Qu.: 74.36     3rd Qu.: 16.94     3rd Qu.: 286.933    3rd Qu.: 4.032     3rd Qu.:1
## Max. :253.01      Max. : 163.33      Max. :161.96      Max. :26232.208     Max. : 75.659      Max. :4
## avg_yaw_arm      stddev_yaw_arm      var_yaw_arm      gyros_arm_x      gyros_arm_y      gyros
## Min. : -173.440    Min. : 0.000      Min. : 0.000      Min. : -6.37000     Min. : -3.4000      Min.
## 1st Qu.: -26.159    1st Qu.: 1.645     1st Qu.: 2.706     1st Qu.: -1.32000    1st Qu.: -0.7900     1st Q
## Median : 0.000      Median : 15.575     Median : 242.577     Median : 0.06000     Median : -0.2400     Median
## Mean : 2.586      Mean : 21.167      Mean : 897.995      Mean : 0.05014      Mean : -0.2623      Mean
## 3rd Qu.: 35.288     3rd Qu.: 35.959     3rd Qu.: 1293.088    3rd Qu.: 1.56000     3rd Qu.: 0.1400     3rd Q
## Max. : 152.000      Max. :158.079      Max. :24988.953      Max. : 4.87000      Max. : 2.8400      Max.
## accel_arm_y      accel_arm_z      magnet_arm_x      magnet_arm_y      magnet_arm_z      kurtosis_roll
## Min. : -318.0      Min. : -630.00     Min. : -584.0      Min. : -386.0      Min. : -597.0      Length:11776
## 1st Qu.: -54.0      1st Qu.: -143.00    1st Qu.: -299.0     1st Qu.: -9.0      1st Qu.: 131.8      Class :character
## Median : 12.0      Median : -47.00     Median : 292.0      Median : 200.0      Median : 442.5      Mode :character
## Mean : 31.9      Mean : -70.72      Mean : 193.7      Mean : 156.5      Mean : 305.5
## 3rd Qu.: 137.0      3rd Qu.: 24.00      3rd Qu.: 640.0      3rd Qu.: 324.0      3rd Qu.: 543.0
## Max. : 308.0      Max. : 271.00      Max. : 780.0      Max. : 583.0      Max. : 694.0
## kurtosis_yaw_arm      skewness_roll_arm      skewness_pitch_arm      skewness_yaw_arm      max_roll_arm      max_p
## Length:11776      Length:11776      Length:11776      Length:11776      Min. : -65.300      Min.
## Class :character      Class :character      Class :character      Class :character      1st Qu.: -3.000      1st Q
## Mode :character      Mode :character      Mode :character      Mode :character      Median : 0.000      Median
## Mean : 8.876      Mean
## 3rd Qu.: 19.700      3rd Q
## Max. : 85.500      Max.
## min_roll_arm      min_pitch_arm      min_yaw_arm      amplitude_roll_arm      amplitude_pitch_arm      amplitude
## Min. : -89.10      Min. : -179.00     Min. : 2.00      Min. : 0.00      Min. : 0.00      Min. : 0
## 1st Qu.: -43.50     1st Qu.: -68.90     1st Qu.: 8.00      1st Qu.: 5.05      1st Qu.: 7.90      1st Qu.:1
## Median : -23.10      Median : -32.80     Median :13.00      Median : 26.90      Median : 53.40      Median :2
## Mean : -22.94      Mean : -32.62      Mean :14.26      Mean : 31.82      Mean : 67.37      Mean :2
## 3rd Qu.: 0.00      3rd Qu.: 0.00      3rd Qu.:18.00      3rd Qu.: 51.12      3rd Qu.:114.60      3rd Qu.:2
## Max. : 66.40      Max. : 152.00      Max. :38.00      Max. :118.00      Max. :359.00      Max. :5
## pitch_dumbbell      yaw_dumbbell      kurtosis_roll_dumbbell      kurtosis_picth_dumbbell      kurtosis_yaw_dum
## Min. : -149.59      Min. : -147.113     Length:11776      Length:11776      Length:11776
## 1st Qu.: -40.46     1st Qu.: -77.510     Class :character      Class :character      Class :character
## Median : -20.96      Median : -2.301      Mode :character      Mode :character      Mode :character
## Mean : -10.72      Mean : 2.118
## 3rd Qu.: 17.57      3rd Qu.: 81.001
## Max. : 137.03      Max. : 154.223
## skewness_pitch_dumbbell      skewness_yaw_dumbbell      max_roll_dumbbell      max_picth_dumbbell      max_yaw_dumbbell
## Length:11776      Length:11776      Min. : -70.10      Min. : -103.70      Length:11776
## Class :character      Class :character      1st Qu.: -26.00      1st Qu.: -65.15      Class :character
## Mode :character      Mode :character      Median : 16.80      Median : 43.00      Mode :character
## Mean : 16.05      Mean : 34.14
## 3rd Qu.: 50.65      3rd Qu.: 133.40
## Max. :137.00      Max. : 154.50

```

```

## min_pitch_dumbbell min_yaw_dumbbell amplitude_roll_dumbbell amplitude_pitch_dumbbell amplitude_yaw_dumbbell
## Min. : -144.30 Length:11776 Min. : 0.00 Min. : 0.00 Length:11776
## 1st Qu.: -89.10 Class :character 1st Qu.: 15.78 1st Qu.: 17.31 Class :character
## Median : -61.50 Mode :character Median : 36.43 Median : 42.26 Mode :character
## Mean : -31.42 Mean : 57.47 Mean : 65.56
## 3rd Qu.: 23.00 3rd Qu.: 87.69 3rd Qu.: 98.56
## Max. : 116.60 Max. : 233.19 Max. : 273.59
## var_accel_dumbbell avg_roll_dumbbell stddev_roll_dumbbell var_roll_dumbbell avg_pitch_dumbbell stddev_pitch_dumbbell
## Min. : 0.000 Min. : -128.96 Min. : 0.000 Min. : 0.00 Min. : -70.53 Min. : 0.000
## 1st Qu.: 0.401 1st Qu.: -12.18 1st Qu.: 4.641 1st Qu.: 21.54 1st Qu.: -39.22 1st Qu.: 0.401
## Median : 1.131 Median : 51.79 Median : 12.931 Median : 167.22 Median : -19.93 Median : 1.131
## Mean : 4.745 Mean : 24.73 Mean : 21.340 Mean : 1087.36 Mean : -11.86 Mean : 4.745
## 3rd Qu.: 3.464 3rd Qu.: 65.11 3rd Qu.: 26.949 3rd Qu.: 726.38 3rd Qu.: 12.57 3rd Qu.: 3.464
## Max. : 230.428 Max. : 125.99 Max. : 123.778 Max. : 15321.01 Max. : 94.28 Max. : 230.428
## var_pitch_dumbbell avg_yaw_dumbbell stddev_yaw_dumbbell var_yaw_dumbbell gyros_dumbbell_x gyros_dumbbell_y
## Min. : 0.00 Min. : -109.967 Min. : 0.000 Min. : 0.00 Min. : -1.9900 Min. : 0.000
## 1st Qu.: 14.56 1st Qu.: -74.671 1st Qu.: 4.054 1st Qu.: 16.44 1st Qu.: -0.0300 1st Qu.: 14.56
## Median : 69.58 Median : -0.727 Median : 10.505 Median : 110.35 Median : 0.1300 Median : 69.58
## Mean : 391.28 Mean : 1.697 Mean : 16.460 Mean : 555.73 Mean : 0.1733 Mean : 391.28
## 3rd Qu.: 384.29 3rd Qu.: 71.199 3rd Qu.: 24.530 3rd Qu.: 602.12 3rd Qu.: 0.3700 3rd Qu.: 384.29
## Max. : 6836.02 Max. : 130.879 Max. : 99.563 Max. : 9912.85 Max. : 2.2000 Max. : 6836.02
## accel_dumbbell_x accel_dumbbell_y accel_dumbbell_z magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z
## Min. : -237.00 Min. : -182.00 Min. : -334.00 Min. : -643.0 Min. : -3600.0 Min. : -500.0
## 1st Qu.: -50.00 1st Qu.: -9.00 1st Qu.: -142.00 1st Qu.: -535.0 1st Qu.: 231.0 1st Qu.: -50.0
## Median : -8.00 Median : 41.00 Median : -1.00 Median : -479.5 Median : 310.0 Median : -8.00
## Mean : -28.31 Mean : 52.67 Mean : -38.33 Mean : -324.4 Mean : 216.7 Mean : -28.31
## 3rd Qu.: 11.00 3rd Qu.: 112.00 3rd Qu.: 39.00 3rd Qu.: -296.0 3rd Qu.: 389.0 3rd Qu.: 11.00
## Max. : 224.00 Max. : 315.00 Max. : 318.00 Max. : 592.0 Max. : 633.0 Max. : 224.00
## pitch_forearm yaw_forearm kurtosis_roll_forearm kurtosis_pitch_forearm kurtosis_yaw_forearm
## Min. : -72.500 Min. : -180.00 Length:11776 Length:11776 Length:11776
## 1st Qu.: 0.000 1st Qu.: -69.03 Class :character Class :character Class :character
## Median : 9.605 Median : 0.00 Mode :character Mode :character Mode :character
## Mean : 11.012 Mean : 19.53
## 3rd Qu.: 28.800 3rd Qu.: 110.00
## Max. : 88.700 Max. : 180.00
## skewness_pitch_forearm skewness_yaw_forearm max_roll_forearm max_pitch_forearm max_yaw_forearm
## Length:11776 Length:11776 Min. : -63.70 Min. : -151.0 Length:11776
## Class :character Class :character 1st Qu.: 0.00 1st Qu.: 0.0 Class :character
## Mode :character Mode :character Median : 28.70 Median : 117.0 Mode :character
## Mean : 26.55 Mean : 82.8
## 3rd Qu.: 46.35 3rd Qu.: 175.0
## Max. : 89.80 Max. : 180.0
## min_yaw_forearm amplitude_roll_forearm amplitude_pitch_forearm amplitude_yaw_forearm total_accel
## Length:11776 Min. : 0.00 Min. : 0.0 Length:11776 Min. : 0.0
## Class :character 1st Qu.: 1.65 1st Qu.: 2.0 Class :character 1st Qu.: 29.0
## Mode :character Median : 19.42 Median : 88.1 Mode :character Median : 36.0
## Mean : 25.49 Mean : 144.5 Mean : 34.0
## 3rd Qu.: 39.55 3rd Qu.: 350.0 3rd Qu.: 41.0
## Max. : 120.30 Max. : 359.0 Max. : 78.0
## avg_roll_forearm stddev_roll_forearm var_roll_forearm avg_pitch_forearm stddev_pitch_forearm var_pitch_forearm
## Min. : -177.13 Min. : 0.000 Min. : 0.000 Min. : -65.25 Min. : 0.000 Min. : 0.000
## 1st Qu.: 0.00 1st Qu.: 0.456 1st Qu.: 0.208 1st Qu.: 0.00 1st Qu.: 0.448 1st Qu.: 0.000
## Median : 15.12 Median : 8.264 Median : 68.289 Median : 12.29 Median : 6.104 Median : 15.12
## Mean : 36.23 Mean : 43.719 Mean : 5492.397 Mean : 13.43 Mean : 8.254 Mean : 36.23

```

```
## 3rd Qu.: 116.14 3rd Qu.:100.357 3rd Qu.:10089.391 3rd Qu.: 28.54 3rd Qu.:12.976 3rd Qu.:
## Max. : 177.26 Max. :177.467 Max. :31494.450 Max. : 72.09 Max. :39.561 Max. :
## stddev_yaw_forearm var_yaw_forearm gyros_forearm_x gyros_forearm_y gyros_forearm_z accel_f
## Min. : 0.000 Min. : 0.00 Min. : -3.360 Min. : -6.65000 Min. : -8.0900 Min. :
## 1st Qu.: 0.618 1st Qu.: 0.38 1st Qu.: -0.210 1st Qu.: -1.51000 1st Qu.: -0.2000 1st Qu.
## Median : 26.599 Median : 707.51 Median : 0.050 Median : 0.02000 Median : 0.0700 Median
## Mean : 47.061 Mean : 4999.53 Mean : 0.165 Mean : 0.03386 Mean : 0.1364 Mean :
## 3rd Qu.: 93.162 3rd Qu.: 8680.03 3rd Qu.: 0.580 3rd Qu.: 1.61000 3rd Qu.: 0.4900 3rd Qu.
## Max. :197.508 Max. :39009.33 Max. : 3.970 Max. : 6.13000 Max. : 4.1000 Max. :
## accel_forearm_z magnet_forearm_x magnet_forearm_y magnet_forearm_z classe
## Min. : -410.00 Min. : -1280.0 Min. : -896.0 Min. : -973.0 Length:11776
## 1st Qu.: -182.00 1st Qu.: -617.0 1st Qu.: 11.0 1st Qu.: 203.0 Class :character
## Median : -43.00 Median : -380.0 Median : 589.0 Median : 515.0 Mode :character
## Mean : -56.87 Mean : -312.3 Mean : 379.2 Mean : 397.6
## 3rd Qu.: 25.00 3rd Qu.: -73.0 3rd Qu.: 736.0 3rd Qu.: 653.0
## Max. : 291.00 Max. : 666.0 Max. :1480.0 Max. :1080.0
## [ reached getOption("max.print") -- omitted 1 row ]
```

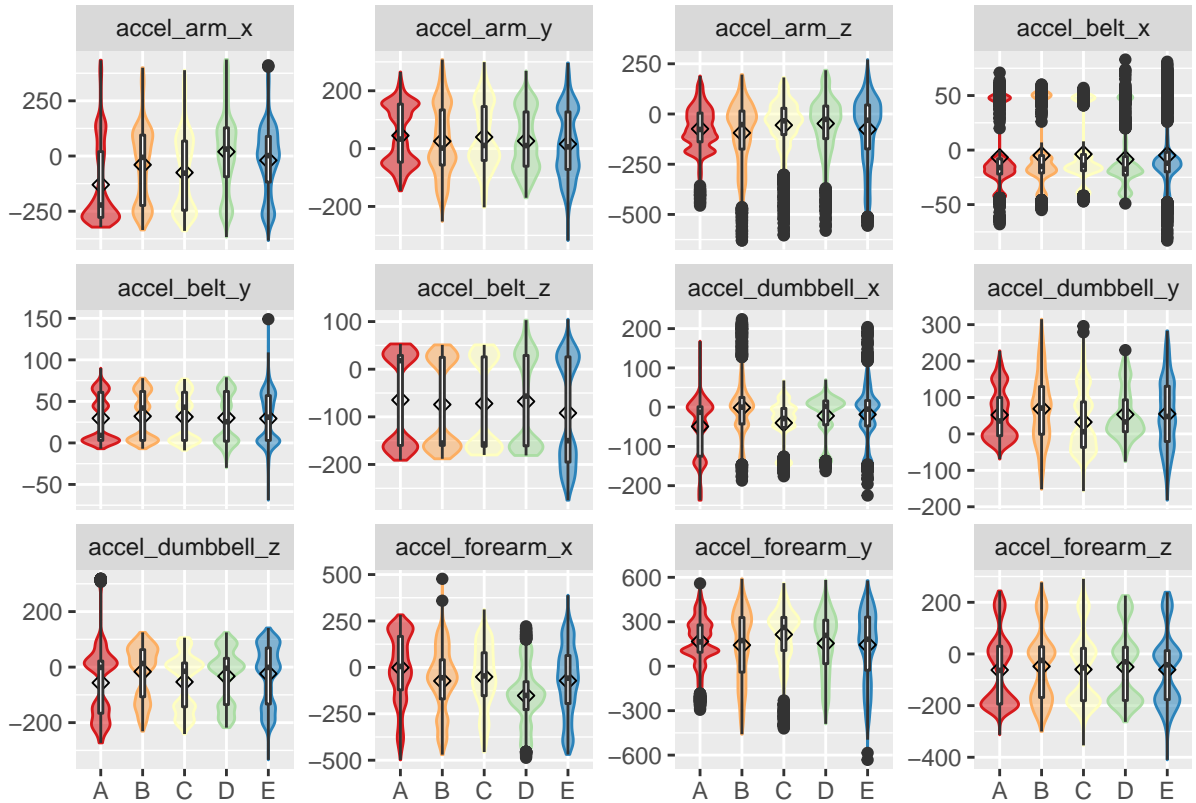
```
summary(test)
```

```
## user_name classe accel_belt_x accel_belt_y accel_belt_z accel_forearm_x accel_f
## adelmo :1556 A:2232 Min. : -120.000 Min. : -36.0 Min. : -268.00 Min. : -496.00 Min. :
## carlitos:1245 B:1518 1st Qu.: -21.000 1st Qu.: 3.0 1st Qu.: -162.00 1st Qu.: -177.00 1st
## charles :1427 C:1368 Median : -14.000 Median : 29.0 Median : -147.00 Median : -58.00 Med
## eurico :1275 D:1286 Mean : -5.326 Mean : 29.7 Mean : -71.51 Mean : -61.83 Mean :
## jeremy :1358 E:1442 3rd Qu.: -5.000 3rd Qu.: 61.0 3rd Qu.: 28.00 3rd Qu.: 77.00 3rd
## pedro : 985 Max. : 85.000 Max. :164.0 Max. : 104.00 Max. : 381.00 Max. :
## accel_arm_x accel_arm_y accel_arm_z accel_dumbbell_x accel_dumbbell_y accel_dum
## Min. : -404.00 Min. : -301.00 Min. : -636.00 Min. : -419.00 Min. : -189.00 Min. : -
## 1st Qu.: -242.00 1st Qu.: -54.00 1st Qu.: -143.00 1st Qu.: -51.00 1st Qu.: -8.00 1st Qu.: -
## Median : -54.00 Median : 16.00 Median : -47.00 Median : -8.00 Median : 43.00 Median :
## Mean : -63.37 Mean : 33.64 Mean : -72.04 Mean : -29.08 Mean : 52.57 Mean :
## 3rd Qu.: 80.00 3rd Qu.: 144.00 3rd Qu.: 23.00 3rd Qu.: 10.00 3rd Qu.: 109.00 3rd Qu.:
## Max. : 431.00 Max. : 303.00 Max. : 292.00 Max. : 235.00 Max. : 299.00 Max. : 3
```

The following figure shows the distribution of the variables evaluated according to the classe.

```
## plot variables as function of classe
trainingSample2 <- trainingSample %>%
  tidyr::pivot_longer(
    cols = starts_with('accel'),
    values_to = 'value'
  )

trainingSample2 %>%
  ggplot(aes(x = classe, y = value)) +
  geom_violin(aes(color = classe, fill = classe, alpha = 0.4)) +
  facet_wrap(~ name, scales = 'free_y') +
  scale_color_brewer(palette = 'Spectral') +
  scale_fill_brewer(palette = 'Spectral') +
  stat_summary(fun = mean, geom = 'point', shape = 23, size = 2) +
  geom_boxplot(width = 0.1) +
  labs(x = "", y = "") +
  theme(legend.position = "none")
```



The result of the analysis with the Random forest algorithm is shown below, where it is possible to observe that the three most important variables are accel_belt_z, accel_dumbbell_y and accel_arm_x.

```
####-> Model Fitting with Random Forest package
set.seed(30131)
rf.prelim <- randomForest(
  x = trainingSample[, -1],
  y = trainingSample$classe,
  #mtry = 2,
  #importance = TRUE,
  do.trace = 50      ## to print every fifty trees
)
```

```
## ntree      OOB      1      2      3      4      5
##   50:    0.03%  0.00%  0.09%  0.00%  0.00%  0.05%
##  100:    0.01%  0.00%  0.04%  0.00%  0.00%  0.00%
##  150:    0.01%  0.00%  0.04%  0.00%  0.00%  0.00%
##  200:    0.01%  0.00%  0.04%  0.00%  0.00%  0.00%
##  250:    0.01%  0.00%  0.04%  0.00%  0.00%  0.00%
##  300:    0.01%  0.00%  0.04%  0.00%  0.00%  0.00%
##  350:    0.01%  0.00%  0.04%  0.00%  0.00%  0.00%
##  400:    0.01%  0.00%  0.04%  0.00%  0.00%  0.00%
##  450:    0.01%  0.00%  0.04%  0.00%  0.00%  0.00%
##  500:    0.01%  0.00%  0.04%  0.00%  0.00%  0.00%
```

```
rf.prelim
```

```
##
```

```

## Call:
## randomForest(x = trainingSample[, -1], y = trainingSample$classe, do.trace = 50)
##           Type of random forest: classification
##           Number of trees: 500
## No. of variables tried at each split: 3
##
##           OOB estimate of  error rate: 0.01%
## Confusion matrix:
##      A      B      C      D      E  class.error
## A 3348      0      0      0      0 0.0000000000
## B      0 2278      0      0      1 0.0004387889
## C      0      0 2054      0      0 0.0000000000
## D      0      0      0 1930      0 0.0000000000
## E      0      0      0      0 2165 0.0000000000

set.seed(1113)
rf = train(
  x = trainingSample[, -c(1, 2)],
  y = trainingSample$classe,
  method = 'rf',
  trControl = trainControl(method = 'oob'),
  allowParallel = TRUE,
  ntree = 300,
  importance = TRUE,
  tuneLength = 10
)

rf

## Random Forest
##
## 11776 samples
## 12 predictor
## 5 classes: 'A', 'B', 'C', 'D', 'E'
##
## No pre-processing
## Resampling results across tuning parameters:
##
## mtry  Accuracy  Kappa
## 2     0.9369056  0.9201533
## 3     0.9367357  0.9199274
## 4     0.9362262  0.9192925
## 5     0.9346128  0.9172553
## 6     0.9311311  0.9128541
## 7     0.9289232  0.9100691
## 8     0.9250170  0.9051182
## 9     0.9235734  0.9032831
## 10    0.9214504  0.9006017
## 12    0.9143173  0.8915417
##
## Accuracy was used to select the optimal model using the largest value.
## The final value used for the model was mtry = 2.

## Compare Predictions with Validation Set
preds <- predict(rf, newdata = test)

```



```
confusionMatrix(preds, test$classe)
```

```
## Confusion Matrix and Statistics
```

```
##
```

```
##           Reference
```

```
## Prediction    A    B    C    D    E
```

```
##           A 2147   65   26   29   2
```

```
##           B   16 1388   38   10  21
```

```
##           C   29   45 1288   50   8
```

```
##           D   36    9   12 1190  13
```

```
##           E    4   11    4    7 1398
```

```
##
```

```
## Overall Statistics
```

```
##
```

```
##           Accuracy : 0.9446
```

```
##           95% CI : (0.9393, 0.9495)
```

```
##           No Information Rate : 0.2845
```

```
##           P-Value [Acc > NIR] : < 2.2e-16
```

```
##
```

```
##           Kappa : 0.9298
```

```
##
```

```
##           McNemar's Test P-Value : 1.952e-09
```

```
##
```

```
## Statistics by Class:
```

```
##
```

```
##           Class: A Class: B Class: C Class: D Class: E
```

```
## Sensitivity      0.9619   0.9144   0.9415   0.9253   0.9695
```

```
## Specificity      0.9783   0.9866   0.9796   0.9893   0.9959
```

```
## Pos Pred Value   0.9462   0.9423   0.9070   0.9444   0.9817
```

```
## Neg Pred Value   0.9848   0.9796   0.9876   0.9854   0.9931
```

```
## Prevalence       0.2845   0.1935   0.1744   0.1639   0.1838
```

```
## Detection Rate   0.2736   0.1769   0.1642   0.1517   0.1782
```

```
## Detection Prevalence 0.2892   0.1877   0.1810   0.1606   0.1815
```

```
## Balanced Accuracy 0.9701   0.9505   0.9606   0.9573   0.9827
```

```
## Show up the most important variable
```

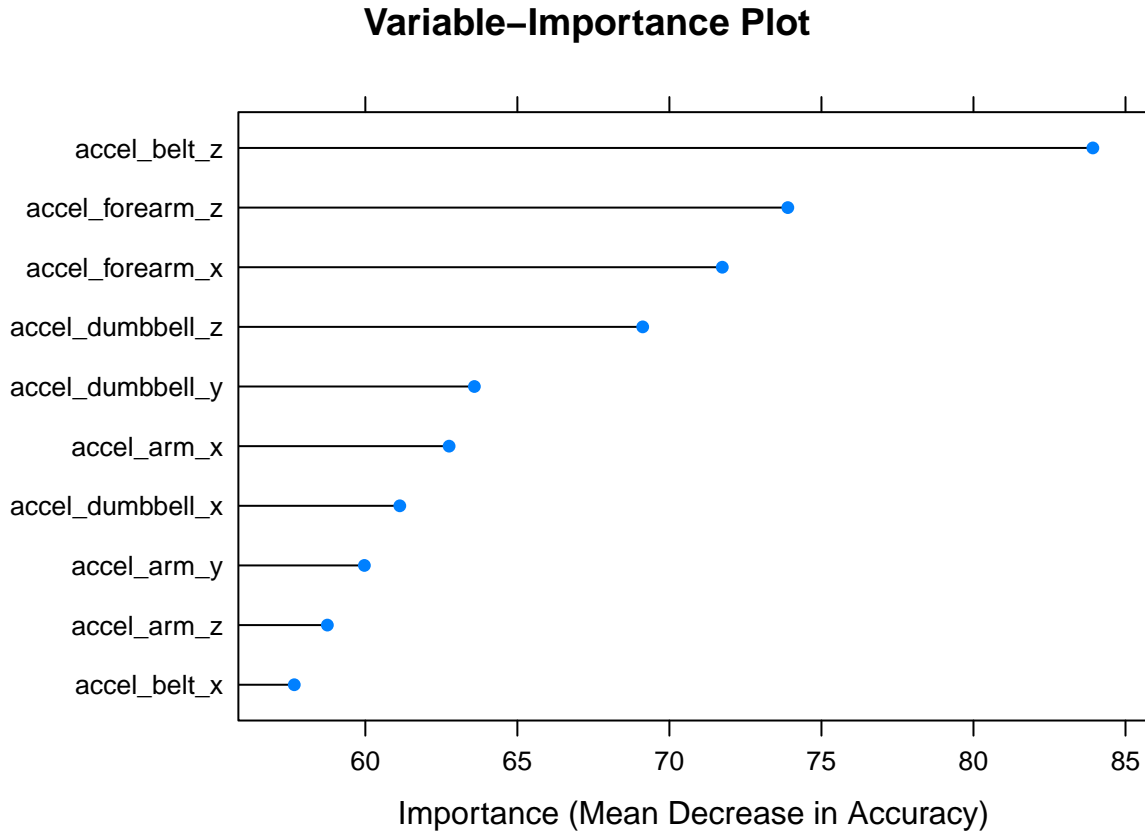
```
rf_plot <- varImp(rf, scale = FALSE, type = 1)
```

```
plot(
```

```
  rf_plot, top = 10, main = 'Variable-Importance Plot',
```

```
  xlab = 'Importance (Mean Decrease in Accuracy)'
```

```
)
```



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