Run.R

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Thu Feb 08 17:23:35 2018

```
library(ggplot2)
library(caret)
library(openxlsx)
library(randomForest)

pacman::p_load(plyr, dplyr, tidyr)
pacman::p_load(readr, haven)
select<-dplyr::select

set.seed(124)

## Load Data
setwd("C:/!KRISTINA/!COURSERA/R_Practical Machine Learning/Course Project")

df_training<-read.csv("pml-training.csv")
df_testing<-read.csv("pml-testing.csv")

head(df_training)
```

```
##   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
## 2
## 3
## 4
## 5
## 6
##   skewness_roll_belt skewness_roll_belt.1 skewness_yaw_belt max_roll_belt
## 1                                                                      NA
## 2                                                                      NA
## 3                                                                      NA
## 4                                                                      NA
## 5                                                                      NA
## 6                                                                      NA
```

```
##   max_picth_belt max_yaw_belt min_roll_belt min_pitch_belt min_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
##   amplitude_roll_belt amplitude_pitch_belt amplitude_yaw_belt
## 1                  NA                   NA
## 2                  NA                   NA
## 3                  NA                   NA
## 4                  NA                   NA
## 5                  NA                   NA
## 6                  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
## 2          337          513
## 3          344          513
## 4          344          512
## 5          337          506
## 6          342          513
##   kurtosis_yaw_arm skewness_roll_arm skewness_pitch_arm skewness_yaw_arm
## 1
## 2
## 3
## 4
## 5
## 6
##   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
## 2      13.13074      -70.63751    -84.71065
## 3      12.85075      -70.27812    -85.14078
## 4      13.43120      -70.39379    -84.87363
## 5      13.37872      -70.42856    -84.85306
## 6      13.38246      -70.81759    -84.46500
##   kurtosis_picth_dumbbell kurtosis_yaw_dumbbell skewness_roll_dumbbell
## 1
## 2
```

```
## 3
## 4
## 5
## 6
##   skewness_pitch_dumbbell skewness_yaw_dumbbell max_roll_dumbbell
## 1                                                              NA
## 2                                                              NA
## 3                                                              NA
## 4                                                              NA
## 5                                                              NA
## 6                                                              NA
##   max_picth_dumbbell max_yaw_dumbbell min_roll_dumbbell min_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
##   min_yaw_dumbbell amplitude_roll_dumbbell amplitude_pitch_dumbbell
## 1                                       NA                      NA
## 2                                       NA                      NA
## 3                                       NA                      NA
## 4                                       NA                      NA
## 5                                       NA                      NA
## 6                                       NA                      NA
##   amplitude_yaw_dumbbell total_accel_dumbbell var_accel_dumbbell
## 1                                         37                NA
## 2                                         37                NA
## 3                                         37                NA
## 4                                         37                NA
## 5                                         37                NA
## 6                                         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
## 2         28.3         -63.9        -153
## 3         28.3         -63.9        -152
## 4         28.1         -63.9        -152
## 5         28.0         -63.9        -152
## 6         27.9         -63.9        -152
##   kurtosis_picth_forearm kurtosis_yaw_forearm skewness_roll_forearm
## 1
## 2
## 3
## 4
## 5
## 6
##   skewness_pitch_forearm skewness_yaw_forearm max_roll_forearm
## 1                                                           NA
## 2                                                           NA
## 3                                                           NA
## 4                                                           NA
## 5                                                           NA
## 6                                                           NA
##   max_picth_forearm max_yaw_forearm min_roll_forearm min_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
##   min_yaw_forearm amplitude_roll_forearm amplitude_pitch_forearm
## 1                                     NA                      NA
## 2                                     NA                      NA
## 3                                     NA                      NA
## 4                                     NA                      NA
## 5                                     NA                      NA
## 6                                     NA                      NA
##   amplitude_yaw_forearm total_accel_forearm var_accel_forearm
## 1                                        36               NA
## 2                                        36               NA
## 3                                        36               NA
## 4                                        36               NA
## 5                                        36               NA
```

```
## 6                                       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
```

```
names(df_training)
```

```
##   [1] "X"                    "user_name"
##   [3] "raw_timestamp_part_1" "raw_timestamp_part_2"
##   [5] "cvtd_timestamp"       "new_window"
##   [7] "num_window"           "roll_belt"
##   [9] "pitch_belt"           "yaw_belt"
##  [11] "total_accel_belt"     "kurtosis_roll_belt"
##  [13] "kurtosis_picth_belt"  "kurtosis_yaw_belt"
##  [15] "skewness_roll_belt"   "skewness_roll_belt.1"
##  [17] "skewness_yaw_belt"    "max_roll_belt"
##  [19] "max_picth_belt"       "max_yaw_belt"
##  [21] "min_roll_belt"        "min_pitch_belt"
##  [23] "min_yaw_belt"         "amplitude_roll_belt"
##  [25] "amplitude_pitch_belt" "amplitude_yaw_belt"
##  [27] "var_total_accel_belt" "avg_roll_belt"
##  [29] "stddev_roll_belt"     "var_roll_belt"
##  [31] "avg_pitch_belt"       "stddev_pitch_belt"
```

```
##  [33] "var_pitch_belt"           "avg_yaw_belt"
##  [35] "stddev_yaw_belt"          "var_yaw_belt"
##  [37] "gyros_belt_x"             "gyros_belt_y"
##  [39] "gyros_belt_z"             "accel_belt_x"
##  [41] "accel_belt_y"             "accel_belt_z"
##  [43] "magnet_belt_x"            "magnet_belt_y"
##  [45] "magnet_belt_z"            "roll_arm"
##  [47] "pitch_arm"                "yaw_arm"
##  [49] "total_accel_arm"          "var_accel_arm"
##  [51] "avg_roll_arm"             "stddev_roll_arm"
##  [53] "var_roll_arm"             "avg_pitch_arm"
##  [55] "stddev_pitch_arm"         "var_pitch_arm"
##  [57] "avg_yaw_arm"              "stddev_yaw_arm"
##  [59] "var_yaw_arm"              "gyros_arm_x"
##  [61] "gyros_arm_y"              "gyros_arm_z"
##  [63] "accel_arm_x"              "accel_arm_y"
##  [65] "accel_arm_z"              "magnet_arm_x"
##  [67] "magnet_arm_y"             "magnet_arm_z"
##  [69] "kurtosis_roll_arm"        "kurtosis_picth_arm"
##  [71] "kurtosis_yaw_arm"         "skewness_roll_arm"
##  [73] "skewness_pitch_arm"       "skewness_yaw_arm"
##  [75] "max_roll_arm"             "max_picth_arm"
##  [77] "max_yaw_arm"              "min_roll_arm"
##  [79] "min_pitch_arm"            "min_yaw_arm"
##  [81] "amplitude_roll_arm"       "amplitude_pitch_arm"
##  [83] "amplitude_yaw_arm"        "roll_dumbbell"
##  [85] "pitch_dumbbell"           "yaw_dumbbell"
##  [87] "kurtosis_roll_dumbbell"   "kurtosis_picth_dumbbell"
##  [89] "kurtosis_yaw_dumbbell"    "skewness_roll_dumbbell"
##  [91] "skewness_pitch_dumbbell"  "skewness_yaw_dumbbell"
##  [93] "max_roll_dumbbell"        "max_picth_dumbbell"
##  [95] "max_yaw_dumbbell"         "min_roll_dumbbell"
##  [97] "min_pitch_dumbbell"       "min_yaw_dumbbell"
##  [99] "amplitude_roll_dumbbell"  "amplitude_pitch_dumbbell"
## [101] "amplitude_yaw_dumbbell"   "total_accel_dumbbell"
## [103] "var_accel_dumbbell"       "avg_roll_dumbbell"
## [105] "stddev_roll_dumbbell"     "var_roll_dumbbell"
## [107] "avg_pitch_dumbbell"       "stddev_pitch_dumbbell"
## [109] "var_pitch_dumbbell"       "avg_yaw_dumbbell"
## [111] "stddev_yaw_dumbbell"      "var_yaw_dumbbell"
## [113] "gyros_dumbbell_x"         "gyros_dumbbell_y"
## [115] "gyros_dumbbell_z"         "accel_dumbbell_x"
## [117] "accel_dumbbell_y"         "accel_dumbbell_z"
## [119] "magnet_dumbbell_x"        "magnet_dumbbell_y"
## [121] "magnet_dumbbell_z"        "roll_forearm"
## [123] "pitch_forearm"            "yaw_forearm"
## [125] "kurtosis_roll_forearm"    "kurtosis_picth_forearm"
## [127] "kurtosis_yaw_forearm"     "skewness_roll_forearm"
## [129] "skewness_pitch_forearm"   "skewness_yaw_forearm"
## [131] "max_roll_forearm"         "max_picth_forearm"
## [133] "max_yaw_forearm"          "min_roll_forearm"
## [135] "min_pitch_forearm"        "min_yaw_forearm"
## [137] "amplitude_roll_forearm"   "amplitude_pitch_forearm"
## [139] "amplitude_yaw_forearm"    "total_accel_forearm"
```

```
## [141] "var_accel_forearm"        "avg_roll_forearm"
## [143] "stddev_roll_forearm"      "var_roll_forearm"
## [145] "avg_pitch_forearm"        "stddev_pitch_forearm"
## [147] "var_pitch_forearm"        "avg_yaw_forearm"
## [149] "stddev_yaw_forearm"       "var_yaw_forearm"
## [151] "gyros_forearm_x"          "gyros_forearm_y"
## [153] "gyros_forearm_z"          "accel_forearm_x"
## [155] "accel_forearm_y"          "accel_forearm_z"
## [157] "magnet_forearm_x"         "magnet_forearm_y"
## [159] "magnet_forearm_z"         "classe"
```

```
## Removing 7 columns - dummy variables
dummy <-c("X", "user_name","raw_timestamp_part_1","raw_timestamp_part_2","cvtd_timestamp" ,
          "new_window" ,"num_window")


## select variable which have large number of "NA" (for <=50% we can imputation value)
varlist<-df_training %>%
  mutate_each(funs(ifelse(.=="", NA,.))) %>%
  summarise_all(funs(sum(is.na(.)))) %>% t(.) %>%
  data.frame(var=row.names(.), countNA=.)%>%
  filter(countNA<=dim(df_training)[1]*0.75)  %>%
  filter(!var %in% dummy)
```

```
## `mutate_each()` is deprecated.
## Use `mutate_all()`, `mutate_at()` or `mutate_if()` instead.
## To map `funs` over all variables, use `mutate_all()`
```

```
varlist$var
```

```
##  [1] roll_belt            pitch_belt           yaw_belt
##  [4] total_accel_belt     gyros_belt_x         gyros_belt_y
##  [7] gyros_belt_z         accel_belt_x         accel_belt_y
## [10] accel_belt_z         magnet_belt_x        magnet_belt_y
## [13] magnet_belt_z        roll_arm             pitch_arm
## [16] yaw_arm              total_accel_arm      gyros_arm_x
## [19] gyros_arm_y          gyros_arm_z          accel_arm_x
## [22] accel_arm_y          accel_arm_z          magnet_arm_x
## [25] magnet_arm_y         magnet_arm_z         roll_dumbbell
## [28] pitch_dumbbell       yaw_dumbbell         total_accel_dumbbell
## [31] gyros_dumbbell_x     gyros_dumbbell_y     gyros_dumbbell_z
## [34] accel_dumbbell_x     accel_dumbbell_y     accel_dumbbell_z
## [37] magnet_dumbbell_x    magnet_dumbbell_y    magnet_dumbbell_z
## [40] roll_forearm         pitch_forearm        yaw_forearm
## [43] total_accel_forearm  gyros_forearm_x      gyros_forearm_y
## [46] gyros_forearm_z      accel_forearm_x      accel_forearm_y
## [49] accel_forearm_z      magnet_forearm_x     magnet_forearm_y
## [52] magnet_forearm_z     classe
## 160 Levels: accel_arm_x accel_arm_y accel_arm_z ... yaw_forearm
```

```
##  Dividing the df_training on train and test
inTrain <- createDataPartition(df_training$classe, p = 0.70, list = F)
train <- df_training[inTrain, ]  %>% select(as.character(varlist$var))
test <- df_training[-inTrain, ] %>% select(as.character(varlist$var))
```

```
## check and  remove variabels which are highly correlated
corMatrix<-cor(select(train,- classe))
var_highCorr<-findCorrelation(corMatrix, verbose = F, cutoff = .95, names=F)
var_highCorr
```

```
## [1] 10  1  8 33
```

```
## Modeling the data caret
mod_rf <- train(classe~., method="rf", data=train[, -var_highCorr],
              trControl = trainControl(method="cv"), number=5)
mod_rf$finalModel
```

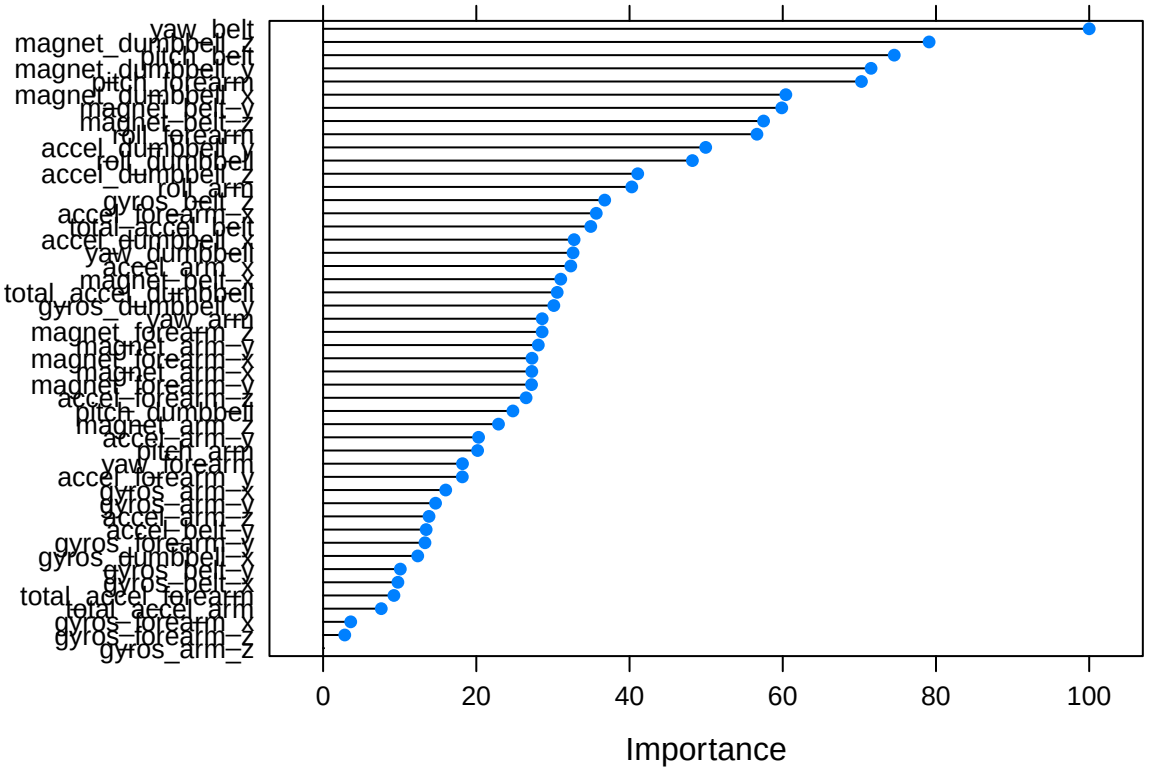
```
##
## Call:
##  randomForest(x = x, y = y, mtry = param$mtry, number = 5)
##                Type of random forest: classification
##                      Number of trees: 500
## No. of variables tried at each split: 2
##
##         OOB estimate of  error rate: 0.75%
## Confusion matrix:
##      A    B    C    D    E  class.error
## A 3903    3    0    0    0 0.0007680492
## B   11 2635   12    0    0 0.0086531226
## C    0   23 2370    3    0 0.0108514190
## D    1    0   41 2206    4 0.0204262877
## E    0    0    0    5 2520 0.0019801980
```

```
## check model in test data
test_pred <- predict(mod_rf, newdata=test)
confusionMatrix(test_pred, test$classe)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1673    5    0    0    0
##          B    1 1131    6    0    0
##          C    0    3 1018   17    3
##          D    0    0    2  947    1
##          E    0    0    0    0 1078
##
## Overall Statistics
##
##               Accuracy : 0.9935
##                 95% CI : (0.9911, 0.9954)
##    No Information Rate : 0.2845
##    P-Value [Acc > NIR] : < 2.2e-16
##
##                  Kappa : 0.9918
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
```

```
## Sensitivity            0.9994   0.9930   0.9922   0.9824   0.9963
## Specificity            0.9988   0.9985   0.9953   0.9994   1.0000
## Pos Pred Value         0.9970   0.9938   0.9779   0.9968   1.0000
## Neg Pred Value         0.9998   0.9983   0.9983   0.9966   0.9992
## Prevalence             0.2845   0.1935   0.1743   0.1638   0.1839
## Detection Rate         0.2843   0.1922   0.1730   0.1609   0.1832
## Detection Prevalence   0.2851   0.1934   0.1769   0.1614   0.1832
## Balanced Accuracy      0.9991   0.9958   0.9937   0.9909   0.9982
```

```
## importance variables
VarImportance_rf <- varImp(mod_rf, scale=T)
plot(VarImportance_rf)
```




```
##  var2 using  randomForest
model_rf_v2 <- randomForest(classe~., data=train[, -var_highCorr], importance=TRUE)
model_rf_v2
```

```
##
## Call:
##  randomForest(formula = classe ~ ., data = train[, -var_highCorr],      importance = TRUE)
##                Type of random forest: classification
##                      Number of trees: 500
## No. of variables tried at each split: 6
##
##         OOB estimate of  error rate: 0.58%
## Confusion matrix:
##      A    B    C    D    E class.error
```

```
## A 3901    4    0    0    1 0.001280082
## B    6 2646    6    0    0 0.004514673
## C    0   18 2374    4    0 0.009181970
## D    0    0   30 2219    3 0.014653641
## E    0    0    0    8 2517 0.003168317
```

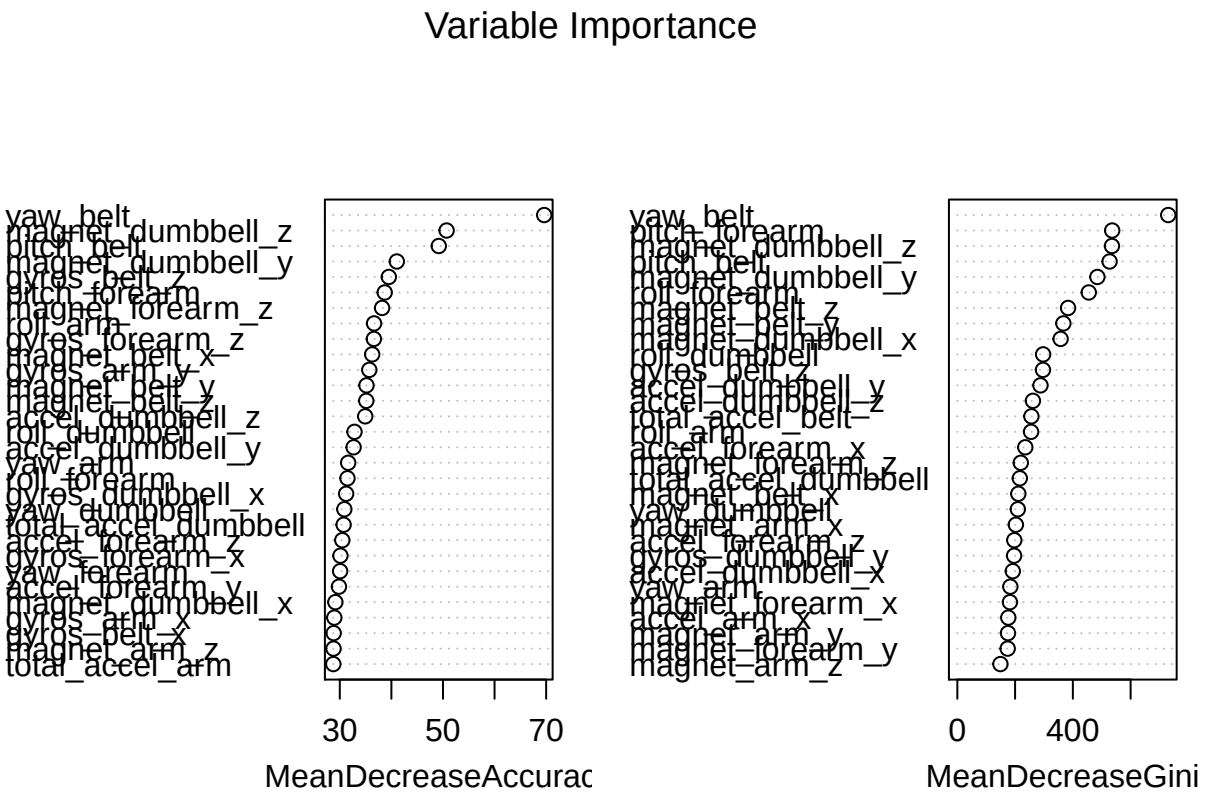
```
varImpPlot(model_rf_v2, top=15, main="Variable Importance")
```

```
## Warning in mtext(labs, side = 2, line = loffset, at = y, adj = 0, col =
## color, : "top" --
```

```
## Warning in title(main = main, xlab = xlab, ylab = ylab, ...): "top" --
##
```

```
## Warning in mtext(labs, side = 2, line = loffset, at = y, adj = 0, col =
## color, : "top" --
```

```
## Warning in title(main = main, xlab = xlab, ylab = ylab, ...): "top" --
##
```




```
confusionMatrix(predict(model_rf_v2, test), test$classe)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1673    5    0    0    0
##          B    1 1133    5    0    0
##          C    0    1 1020   11    3
```

```
##          D    0    0    1  953    2
##          E    0    0    0    0 1077
##
## Overall Statistics
##
##                Accuracy : 0.9951
##                  95% CI : (0.9929, 0.9967)
##     No Information Rate : 0.2845
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.9938
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.9994   0.9947   0.9942   0.9886   0.9954
## Specificity            0.9988   0.9987   0.9969   0.9994   1.0000
## Pos Pred Value         0.9970   0.9947   0.9855   0.9969   1.0000
## Neg Pred Value         0.9998   0.9987   0.9988   0.9978   0.9990
## Prevalence             0.2845   0.1935   0.1743   0.1638   0.1839
## Detection Rate         0.2843   0.1925   0.1733   0.1619   0.1830
## Detection Prevalence   0.2851   0.1935   0.1759   0.1624   0.1830
## Balanced Accuracy      0.9991   0.9967   0.9955   0.9940   0.9977
```

```
### predict 20 test cases available in the test data
testing_pred <- predict(mod_rf, newdata=df_testing)
testing_pred
```

```
##  [1] 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
```

```
df_testing_res <-cbind(df_testing, classe=testing_pred)

## save data with resualts
write.csv(df_testing_res, "pml-testing-res.csv")
```