Exercise Method Prediction

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Overview

In this assignment, we will use data collected as part of a Human Activity Recognition (HAR) [1] study and use machine learning to determine how effective the data collected is for prediction of the quality of how the exercise activity is being performed.

The activity is "Unilaterial Dumbbell Biceps Curl". Each participant was asked to perform 10 repetitions, 5 different methods. Essentially, one method was correct, the other four were incorrect in a defined manner. The manner in which the activity was completed is captured in the "classe" field; the definitions of the classe categorizations is shown in the appendix.[2]

Executive Summary

Three models (Decision Tree, Random Forest and Generalized Boosted Method) we applied against the cleaned data. Cross-validation found that the Random Forest provided the most accurate prediction for the given data.

Setting the Environment

```
knitr::opts_chunk$set(echo=FALSE)
# Always set the seed
set.seed(1994)
# Libraries
library(caret)
library(rpart)
library(rattle)
library(randomForest)
library(knitr)
library(corrplot)
library(RColorBrewer)
library(kableExtra)
```

Loading, Cleaning and Arranging the Data

```
# locations of the data
trainURL <- "https://d396qusza40orc.cloudfront.net/predmachlearn/pml-training.csv"
testURL <- "https://d396qusza40orc.cloudfront.net/predmachlearn/pml-testing.csv"
```

```
# read the data in
training <- read.csv(url(trainURL))
testing <- read.csv(url(testURL))
dim(testing)
```

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

We will be working with the training set for now, holding out the testing set for the quiz.

Exploration of the data set using head (shown in the appendix) revealed that the first 7 columns of the data are identifiers that will be removed. Using the is.na function revealed that a number of the fields were almost entirely NA, and those will be removed as well.

```
# capture the exploration and print output in the Appendix
headUC <- head(training, 2)
naUC <- sapply(training, function(x) sum(is.na(x)))
# Remove Identifiers
training <- training[,-(1:7)]
dim(training)
```

```
## [1] 19622   153
```

```
# Remvove NA's
remNA <- sapply(training, function(x) mean(is.na(x))) > 0.975
training <- training[,remNA==FALSE]
dim(training)
```

```
## [1] 19622    86
```

The near zero variance variables will be identified and removed.

```
nearZero <- nearZeroVar(training)
# nearZero
training <- training[,-nearZero]
dim(training)
```

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

The testing set will be broken into trainSet and testSet.

```
# Break the training set into training and test
inTrain <-createDataPartition(training$classe, p=0.7, list=FALSE)
trainSet <- training[inTrain,]
testSet <- training[-inTrain,]
dim(trainSet);dim(testSet)
```

```
## [1] 13737    53
```

```
## [1] 5885   53
```

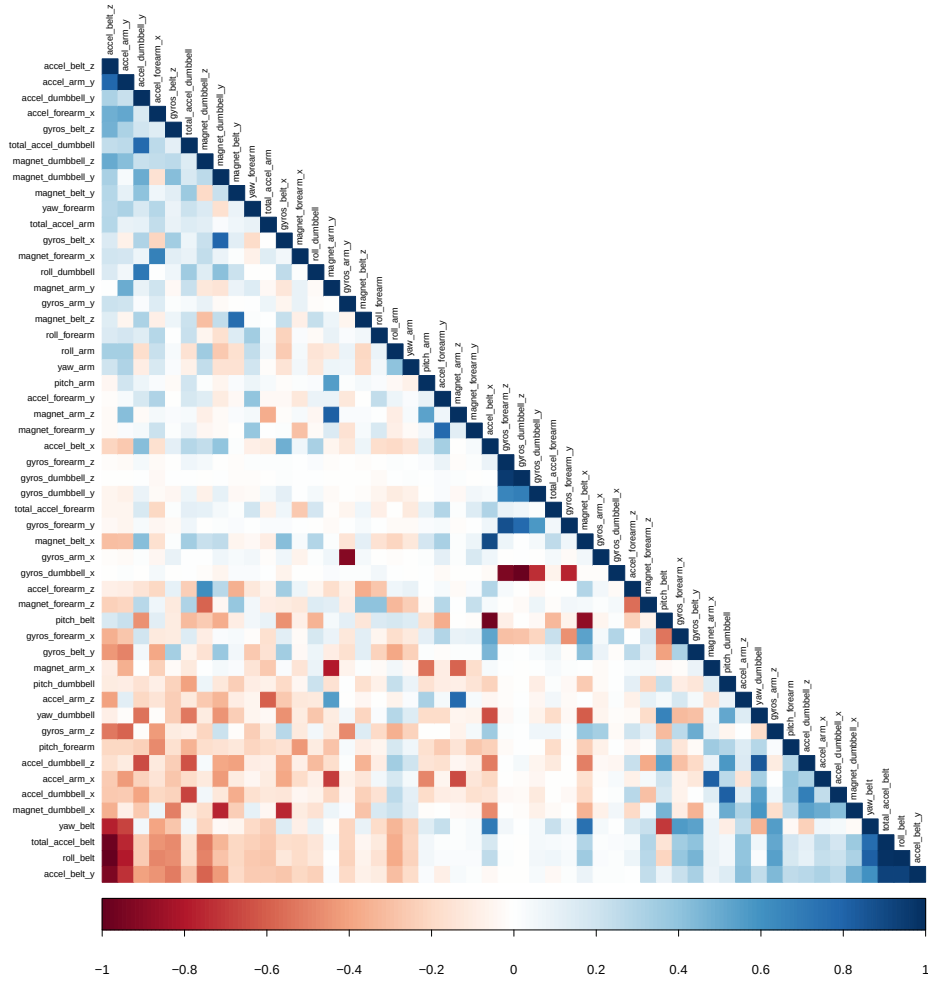
```
# set classe as.factor
trainSet$classe <- as.factor(trainSet$classe)
testSet$classe <- as.factor(testSet$classe)
```

Correlation Analysis

We will look at the number of highly correlated variables to see if a Principal Component Analysis (PCA) should be done.

```
correlationMatrix <- cor(trainSet[,-53])
corrplot(correlationMatrix, order="FPC", method="color", type="lower",
    tl.cex=0.6, tl.col=rgb(0,0,0))
```

fig. 1 - Correlation Table



From the graph, there appears to be a number of $^{+}_{-}$highly correlated variables. If PCA is performed, interptretability will be lost and will not be performed.

PCA will be explored if scalability of the select model becomes necessary.

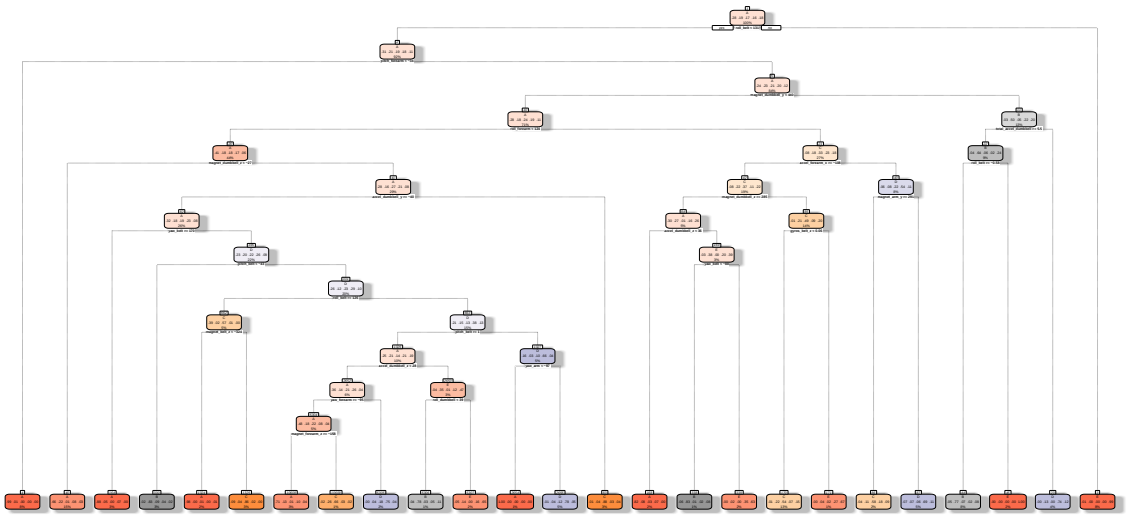
Modeling

Three models will be build with the trainSet data; Decision Tree, Random Forest and Generalized Boosted. The models will be build and cross-validated with the testSet. The model that has the highest accuracy while considering the kappa score will be used against the testing.

Decision Tree

```
mdl_dt <- rpart(classe~., data=trainSet, method="class")
fancyRpartPlot(mdl_dt, sub="", palettes=c("Reds", "Greys"))
```

fig 2. - Decision Tree



```
prd_dt <- predict(mdl_dt, newdata=testSet, type="class")
cm_dt <- confusionMatrix(prd_dt, testSet$classe)
cm_dt
```

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

```
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1563  227   29  105   33
##          B   41  613   52   25   65
##          C   43  208  876  103  135
##          D   20   72   69  652   70
##          E    7   19    0   79  779
##
## Overall Statistics
##
##                Accuracy : 0.7618
##                  95% CI : (0.7507, 0.7726)
##     No Information Rate : 0.2845
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.6971
##
##  Mcnemar's Test P-Value : < 2.2e-16
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.9337   0.5382   0.8538   0.6763   0.7200
## Specificity            0.9064   0.9614   0.8994   0.9531   0.9781
## Pos Pred Value         0.7987   0.7701   0.6418   0.7384   0.8812
## Neg Pred Value         0.9717   0.8966   0.9668   0.9376   0.9394
## Prevalence             0.2845   0.1935   0.1743   0.1638   0.1839
## Detection Rate         0.2656   0.1042   0.1489   0.1108   0.1324
## Detection Prevalence   0.3325   0.1353   0.2319   0.1500   0.1502
## Balanced Accuracy      0.9201   0.7498   0.8766   0.8147   0.8491
```

```
acc_dt <- round(cm_dt$overall['Accuracy'],4)
kap_dt <- round(cm_dt$overall['Kappa'],4)
```

```
set.seed(1994)
ctrl_rf <- trainControl(method="cv", number=3, verboseIter=FALSE)
mdl_rf <- train(classe~., data=trainSet, method="rf",
    trControl=ctrl_rf)
mdl_rf$finalModel
```

Random Forest

```
##
## Call:
##  randomForest(x = x, y = y, mtry = param$mtry)
##                Type of random forest: classification
##                      Number of trees: 500
## No. of variables tried at each split: 27
##
```

```
##         OOB estimate of  error rate: 0.68%
## Confusion matrix:
##      A    B    C    D    E class.error
## A 3897    6    2    0    1 0.002304147
## B   18 2635    5    0    0 0.008653123
## C    0   14 2372   10    0 0.010016694
## D    0    0   22 2228    2 0.010657194
## E    0    2    5    7 2511 0.005544554
```

```
prd_rf <- predict(mdl_rf, newdata=testSet)
cm_rf <- confusionMatrix(prd_rf, testSet$classe)
cm_rf
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1671   13    0    0    0
##          B    0 1125    8    0    0
##          C    2    1 1015   11    2
##          D    0    0    3  951    1
##          E    1    0    0    2 1079
##
## Overall Statistics
##
##                Accuracy : 0.9925
##                  95% CI : (0.99, 0.9946)
##     No Information Rate : 0.2845
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.9905
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.9982   0.9877   0.9893   0.9865   0.9972
## Specificity            0.9969   0.9983   0.9967   0.9992   0.9994
## Pos Pred Value         0.9923   0.9929   0.9845   0.9958   0.9972
## Neg Pred Value         0.9993   0.9971   0.9977   0.9974   0.9994
## Prevalence             0.2845   0.1935   0.1743   0.1638   0.1839
## Detection Rate         0.2839   0.1912   0.1725   0.1616   0.1833
## Detection Prevalence   0.2862   0.1925   0.1752   0.1623   0.1839
## Balanced Accuracy      0.9976   0.9930   0.9930   0.9929   0.9983
```

```
acc_rf <- round(cm_rf$overall['Accuracy'],4)
kap_rf <- round(cm_rf$overall['Kappa'],4)
```

```
set.seed(1994)
ctrl_gbm <- trainControl(method="repeatedcv", number=5, repeats=1)
```

```
mdl_gbm <- train(classe~., data=trainSet, method="gbm",
    trControl=ctrl_gbm, verbose=FALSE)
mdl_gbm$finalModel
```

Generalized Boosted Method

```
## A gradient boosted model with multinomial loss function.
## 150 iterations were performed.
## There were 52 predictors of which 52 had non-zero influence.
```

```
prd_gbm <- predict(mdl_gbm, newdata=testSet)
cm_gbm <- confusionMatrix(prd_gbm, testSet$classe)
cm_gbm
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction    A    B    C    D    E
##          A 1643   40    0    0    0
##          B   15 1077   44    7    5
##          C    7   20  971   28    5
##          D    8    2    9  921   15
##          E    1    0    2    8 1057
##
## Overall Statistics
##
##                Accuracy : 0.9633
##                  95% CI : (0.9582, 0.968)
##     No Information Rate : 0.2845
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.9536
##
##  Mcnemar's Test P-Value : 1.163e-08
##
## Statistics by Class:
##
##                      Class: A Class: B Class: C Class: D Class: E
## Sensitivity            0.9815   0.9456   0.9464   0.9554   0.9769
## Specificity            0.9905   0.9850   0.9877   0.9931   0.9977
## Pos Pred Value         0.9762   0.9382   0.9418   0.9644   0.9897
## Neg Pred Value         0.9926   0.9869   0.9887   0.9913   0.9948
## Prevalence             0.2845   0.1935   0.1743   0.1638   0.1839
## Detection Rate         0.2792   0.1830   0.1650   0.1565   0.1796
## Detection Prevalence   0.2860   0.1951   0.1752   0.1623   0.1815
## Balanced Accuracy      0.9860   0.9653   0.9670   0.9742   0.9873
```

```
acc_gbm <- round(cm_gbm$overall['Accuracy'],4)
kap_gbm <- round(cm_gbm$overall['Kappa'],4)
```

Results

```
result_dt <- as.data.frame(rbind(c(acc_dt,kap_dt)))
result_rf <- as.data.frame(rbind(c(acc_rf,kap_rf)))
result_gbm <- as.data.frame(rbind(c(acc_gbm,kap_gbm)))
tab <- rbind(result_dt, result_rf, result_gbm)
row.names(tab) <- c("Decision Tree", "Random Forest", "Generalized Boosted Method")
```

```
# Pretty output
kable(tab, "latex", caption="Results") %>%
    kable_styling(full_width=FALSE, position="left",
        latex_options=c("striped","hold_position"), stripe_index=c(2),
        stripe_color = "yellow")
```

Table 1: Results

	Accuracy	Kappa
Decision Tree	0.7618	0.6971
Random Forest	0.9925	0.9905
Generalized Boosted Method	0.9633	0.9536

Based on the Accuracy and Kappa values for each of the models, the Random Forest Model is selected. Both Accuracy and the Kappa values are higher than the others.

Predictions for the Quiz

The selected model will be applied to testing data to predict the classe for the 20 rows of data

```
prd_quiz <- predict(mdl_rf, newdata=testing)
prd_quiz
```

```
##  [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
```

Appendix

Overview Information: [1] http://groupware.les.inf.puc-rio.br/har , accessed 20 July 2020.

[2] "Qualitative Activity Recognition of Weight Lifting Exercises", Velloso, E.; Bulling, A.; Gellersen, H.; Ugulino, W.; Fuks, H. Qualitative Activity Recognition of Weight Lifting Exercises. Proceedings of 4th International Conference in Cooperation with SIGCHI (Augmented Human '13) . Stuttgart, Germany: ACM SIGCHI, 2013. http://groupware.les.inf.puc-rio.br/public/papers/2013.Velloso.QAR-WLE.pdf , Accessed 20 July 2020

Dataset provided by Instructor taken from:

- http://web.archive.org/web/20161224072740/http:/groupware.les.inf.puc-rio.br/har

Visualization

- The Classe decision tree was plotted using the R Rattle package.

"classe" Definitions

Class A - Exactly according to the specification

Class B - Throwing the elbows to the front

Class C - Lifting the dumbbell only halfway

Class D - Lowering the dumbbell only halfway

Class E - Throwing the hips to the front

```
print("Head Information Before Cleaning:")
```

Before Cleaning Head and is.na's

```
## [1] "Head Information Before Cleaning:"
```

```
headUC
```

```
##   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
##   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
##   kurtosis_roll_belt kurtosis_picth_belt kurtosis_yaw_belt skewness_roll_belt
## 1
## 2
##   skewness_roll_belt.1 skewness_yaw_belt max_roll_belt max_picth_belt
## 1                                                   NA             NA
## 2                                                   NA             NA
##   max_yaw_belt min_roll_belt min_pitch_belt min_yaw_belt amplitude_roll_belt
## 1                       NA             NA                                NA
## 2                       NA             NA                                NA
##   amplitude_pitch_belt amplitude_yaw_belt var_total_accel_belt avg_roll_belt
## 1                   NA                                     NA            NA
## 2                   NA                                     NA            NA
##   stddev_roll_belt var_roll_belt avg_pitch_belt stddev_pitch_belt
## 1               NA            NA             NA                NA
## 2               NA            NA             NA                NA
##   var_pitch_belt avg_yaw_belt stddev_yaw_belt var_yaw_belt gyros_belt_x
## 1             NA           NA              NA           NA         0.00
## 2             NA           NA              NA           NA         0.02
##   gyros_belt_y gyros_belt_z accel_belt_x accel_belt_y accel_belt_z
## 1            0        -0.02          -21            4           22
## 2            0        -0.02          -22            4           22
```

```
##   magnet_belt_x magnet_belt_y magnet_belt_z roll_arm pitch_arm yaw_arm
## 1            -3           599          -313     -128      22.5    -161
## 2            -7           608          -311     -128      22.5    -161
##   total_accel_arm var_accel_arm avg_roll_arm stddev_roll_arm var_roll_arm
## 1              34            NA           NA              NA           NA
## 2              34            NA           NA              NA           NA
##   avg_pitch_arm stddev_pitch_arm var_pitch_arm avg_yaw_arm stddev_yaw_arm
## 1            NA               NA            NA          NA             NA
## 2            NA               NA            NA          NA             NA
##   var_yaw_arm gyros_arm_x gyros_arm_y gyros_arm_z accel_arm_x accel_arm_y
## 1          NA        0.00        0.00       -0.02        -288         109
## 2          NA        0.02       -0.02       -0.02        -290         110
##   accel_arm_z magnet_arm_x magnet_arm_y magnet_arm_z kurtosis_roll_arm
## 1        -123         -368          337          516
## 2        -125         -369          337          513
##   kurtosis_picth_arm kurtosis_yaw_arm skewness_roll_arm skewness_pitch_arm
## 1
## 2
##   skewness_yaw_arm max_roll_arm max_picth_arm max_yaw_arm min_roll_arm
## 1                           NA            NA          NA           NA
## 2                           NA            NA          NA           NA
##   min_pitch_arm min_yaw_arm amplitude_roll_arm amplitude_pitch_arm
## 1            NA          NA                 NA                  NA
## 2            NA          NA                 NA                  NA
##   amplitude_yaw_arm roll_dumbbell pitch_dumbbell yaw_dumbbell
## 1                NA      13.05217      -70.49400    -84.87394
## 2                NA      13.13074      -70.63751    -84.71065
##   kurtosis_roll_dumbbell kurtosis_picth_dumbbell kurtosis_yaw_dumbbell
## 1
## 2
##   skewness_roll_dumbbell skewness_pitch_dumbbell skewness_yaw_dumbbell
## 1
## 2
##   max_roll_dumbbell max_picth_dumbbell max_yaw_dumbbell min_roll_dumbbell
## 1                NA                 NA                                NA
## 2                NA                 NA                                NA
##   min_pitch_dumbbell min_yaw_dumbbell amplitude_roll_dumbbell
## 1                 NA                                      NA
## 2                 NA                                      NA
##   amplitude_pitch_dumbbell amplitude_yaw_dumbbell total_accel_dumbbell
## 1                       NA                                         37
## 2                       NA                                         37
##   var_accel_dumbbell avg_roll_dumbbell stddev_roll_dumbbell var_roll_dumbbell
## 1                 NA                NA                   NA                NA
## 2                 NA                NA                   NA                NA
##   avg_pitch_dumbbell stddev_pitch_dumbbell var_pitch_dumbbell avg_yaw_dumbbell
## 1                 NA                    NA                 NA               NA
## 2                 NA                    NA                 NA               NA
##   stddev_yaw_dumbbell var_yaw_dumbbell gyros_dumbbell_x gyros_dumbbell_y
## 1                  NA               NA                0            -0.02
## 2                  NA               NA                0            -0.02
##   gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y accel_dumbbell_z
## 1                0             -234               47             -271
## 2                0             -233               47             -269
```

```
##   magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z roll_forearm
## 1              -559               293               -65         28.4
## 2              -555               296               -64         28.3
##   pitch_forearm yaw_forearm kurtosis_roll_forearm kurtosis_picth_forearm
## 1         -63.9        -153
## 2         -63.9        -153
##   kurtosis_yaw_forearm skewness_roll_forearm skewness_pitch_forearm
## 1
## 2
##   skewness_yaw_forearm max_roll_forearm max_picth_forearm max_yaw_forearm
## 1                                   NA                NA
## 2                                   NA                NA
##   min_roll_forearm min_pitch_forearm min_yaw_forearm amplitude_roll_forearm
## 1               NA                NA                                    NA
## 2               NA                NA                                    NA
##   amplitude_pitch_forearm amplitude_yaw_forearm total_accel_forearm
## 1                      NA                                       36
## 2                      NA                                       36
##   var_accel_forearm avg_roll_forearm stddev_roll_forearm var_roll_forearm
## 1                NA                NA                  NA               NA
## 2                NA                NA                  NA               NA
##   avg_pitch_forearm stddev_pitch_forearm var_pitch_forearm avg_yaw_forearm
## 1                NA                   NA                NA              NA
## 2                NA                   NA                NA              NA
##   stddev_yaw_forearm var_yaw_forearm gyros_forearm_x gyros_forearm_y
## 1                 NA              NA            0.03               0
## 2                 NA              NA            0.02               0
##   gyros_forearm_z accel_forearm_x accel_forearm_y accel_forearm_z
## 1           -0.02             192             203            -215
## 2           -0.02             192             203            -216
##   magnet_forearm_x magnet_forearm_y magnet_forearm_z classe
## 1              -17              654              476      A
## 2              -18              661              473      A
```

```
print("is.na Information Before Cleaning")
```

```
## [1] "is.na Information Before Cleaning"
```

```
naUC
```

```
##                        X                user_name     raw_timestamp_part_1
##                        0                        0                        0
##     raw_timestamp_part_2           cvtd_timestamp               new_window
##                        0                        0                        0
##               num_window                roll_belt               pitch_belt
##                        0                        0                        0
##                yaw_belt         total_accel_belt       kurtosis_roll_belt
##                        0                        0                        0
##      kurtosis_picth_belt        kurtosis_yaw_belt       skewness_roll_belt
##                        0                        0                        0
##     skewness_roll_belt.1        skewness_yaw_belt            max_roll_belt
##                        0                        0                    19216
##           max_picth_belt             max_yaw_belt            min_roll_belt
```

```
##                   19216                       0                   19216
##           min_pitch_belt            min_yaw_belt      amplitude_roll_belt
##                   19216                       0                   19216
##     amplitude_pitch_belt      amplitude_yaw_belt     var_total_accel_belt
##                   19216                       0                   19216
##            avg_roll_belt         stddev_roll_belt            var_roll_belt
##                   19216                   19216                   19216
##           avg_pitch_belt        stddev_pitch_belt           var_pitch_belt
##                   19216                   19216                   19216
##             avg_yaw_belt          stddev_yaw_belt             var_yaw_belt
##                   19216                   19216                   19216
##             gyros_belt_x            gyros_belt_y            gyros_belt_z
##                       0                       0                       0
##             accel_belt_x            accel_belt_y            accel_belt_z
##                       0                       0                       0
##            magnet_belt_x           magnet_belt_y           magnet_belt_z
##                       0                       0                       0
##                roll_arm               pitch_arm                 yaw_arm
##                       0                       0                       0
##          total_accel_arm           var_accel_arm            avg_roll_arm
##                       0                   19216                   19216
##          stddev_roll_arm            var_roll_arm           avg_pitch_arm
##                   19216                   19216                   19216
##         stddev_pitch_arm           var_pitch_arm             avg_yaw_arm
##                   19216                   19216                   19216
##           stddev_yaw_arm             var_yaw_arm             gyros_arm_x
##                   19216                   19216                       0
##              gyros_arm_y             gyros_arm_z             accel_arm_x
##                       0                       0                       0
##              accel_arm_y             accel_arm_z            magnet_arm_x
##                       0                       0                       0
##             magnet_arm_y            magnet_arm_z       kurtosis_roll_arm
##                       0                       0                       0
##       kurtosis_picth_arm        kurtosis_yaw_arm       skewness_roll_arm
##                       0                       0                       0
##       skewness_pitch_arm        skewness_yaw_arm            max_roll_arm
##                       0                       0                   19216
##            max_picth_arm             max_yaw_arm            min_roll_arm
##                   19216                   19216                   19216
##            min_pitch_arm             min_yaw_arm      amplitude_roll_arm
##                   19216                   19216                   19216
##      amplitude_pitch_arm       amplitude_yaw_arm           roll_dumbbell
##                   19216                   19216                       0
##           pitch_dumbbell            yaw_dumbbell   kurtosis_roll_dumbbell
##                       0                       0                       0
##  kurtosis_picth_dumbbell   kurtosis_yaw_dumbbell   skewness_roll_dumbbell
##                       0                       0                       0
##  skewness_pitch_dumbbell   skewness_yaw_dumbbell       max_roll_dumbbell
##                       0                       0                   19216
##       max_picth_dumbbell        max_yaw_dumbbell       min_roll_dumbbell
##                   19216                       0                   19216
##       min_pitch_dumbbell        min_yaw_dumbbell  amplitude_roll_dumbbell
##                   19216                       0                   19216
## amplitude_pitch_dumbbell  amplitude_yaw_dumbbell     total_accel_dumbbell
```

```
##                   19216                       0                       0
##      var_accel_dumbbell       avg_roll_dumbbell    stddev_roll_dumbbell
##                   19216                   19216                   19216
##       var_roll_dumbbell      avg_pitch_dumbbell   stddev_pitch_dumbbell
##                   19216                   19216                   19216
##      var_pitch_dumbbell        avg_yaw_dumbbell     stddev_yaw_dumbbell
##                   19216                   19216                   19216
##        var_yaw_dumbbell        gyros_dumbbell_x        gyros_dumbbell_y
##                   19216                       0                       0
##        gyros_dumbbell_z        accel_dumbbell_x        accel_dumbbell_y
##                       0                       0                       0
##        accel_dumbbell_z       magnet_dumbbell_x       magnet_dumbbell_y
##                       0                       0                       0
##       magnet_dumbbell_z            roll_forearm           pitch_forearm
##                       0                       0                       0
##             yaw_forearm   kurtosis_roll_forearm  kurtosis_picth_forearm
##                       0                       0                       0
##    kurtosis_yaw_forearm   skewness_roll_forearm  skewness_pitch_forearm
##                       0                       0                       0
##    skewness_yaw_forearm        max_roll_forearm       max_picth_forearm
##                       0                   19216                   19216
##         max_yaw_forearm        min_roll_forearm       min_pitch_forearm
##                       0                   19216                   19216
##         min_yaw_forearm  amplitude_roll_forearm amplitude_pitch_forearm
##                       0                   19216                   19216
##   amplitude_yaw_forearm     total_accel_forearm       var_accel_forearm
##                       0                       0                   19216
##         avg_roll_forearm     stddev_roll_forearm        var_roll_forearm
##                   19216                   19216                   19216
##        avg_pitch_forearm    stddev_pitch_forearm       var_pitch_forearm
##                   19216                   19216                   19216
##         avg_yaw_forearm       stddev_yaw_forearm         var_yaw_forearm
##                   19216                   19216                   19216
##         gyros_forearm_x         gyros_forearm_y         gyros_forearm_z
##                       0                       0                       0
##         accel_forearm_x         accel_forearm_y         accel_forearm_z
##                       0                       0                       0
##        magnet_forearm_x        magnet_forearm_y        magnet_forearm_z
##                       0                       0                       0
##                  classe
##                       0
```