Weight Lifting Exercise

This human activity recognition research has traditionally focused on discriminating between different activities, i.e. to predict "which" activity was performed at a specific point in time (like with the Daily Living Activities dataset above). The approach we propose for the Weight Lifting Exercises dataset is to investigate "how (well)" an activity was performed by the wearer. The "how (well)" investigation has only received little attention so far, even though it potentially provides useful information for a large variety of applications, such as sports training.

1. Use the below given data set
Data Set
2. Perform the below given activities:
a. Create classification model using different random forest models
b. Verify model goodness of fit
c. Apply all the model validation techniques
d. Make conclusions
e. Plot importance of variables

setwd("C:/Users/Seshan/Desktop")

library(readr)

```r
Weight_lift <- read.csv("Weight lift.csv")

View(Weight_lift)

str(Weight_lift)

data<-Weight_lift

# load libraries

library(caret)

library(randomForest)

library(rpart)

library(rpart.plot)

library(ggplot2)

library(lattice)

library(rattle)


library(C50)

#install.package('devtools') # Only needed if you dont have this installed.

library(devtools)

install_github('adam-m-mcelhinney/helpRFunctions')

library(helpRFunctions)

names(data)

dim(data)

pairs(data[1:10])

# enable multi-core processing

library(doParallel)

cl <- makeCluster(detectCores())

registerDoParallel()
```

```r
set.seed(12345)

dataTrain<-data[1:4004,]

dataTest<-data[4005:4024,]

head(dataTrain)

head(dataTest)

indexNA <- as.vector(sapply(dataTrain[,1:158],function(x) {length(which(is.na(x)))!=0}))

dataTrain <- dataTrain[,!indexNA]

train_control<- trainControl(method="cv", number=10)


model<- train(classe ~., data=dataTrain,trControl=train_control, method="rf")

model

# make predictions

predictions<- predict(model,dataTrain)

# append predictions

pred<- cbind(dataTrain,predictions)

# summarize results

confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)

confusionMatrix

#how do we create a cross validation scheme

control <- trainControl(method = 'repeatedcv',

            number = 10,

            repeats = 3)

seed <-7

metric <- 'Accuracy'

set.seed(seed)
```

```r
mtry <- sqrt(ncol(dataTrain))

tunegrid <- expand.grid(.mtry=mtry)

rf_default <- train(pitch_belt~.,

            data = dataTrain,

            method = 'rf',

            metric = 0,

            tuneGrid = tunegrid,

            trControl = control)

print(rf_default)

#-----------------------------


# make predictions

predictions<- predict(rf_default,dataTest)

# append predictions

pred<- cbind(dataTest,predictions)

# summarize results

confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)

confusionMatrix

varImp(rf_default)

#----------------

# random search for parameters

control <- trainControl(method = 'repeatedcv',

            number = 10,

            repeats = 3,

            search = 'random')
```

```r
# make predictions

predictions<- predict(rf_default,dataTest)


# append predictions

pred<- cbind(dataTest,predictions)


# summarize results

#confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)

confusionMatrix

varImp(random)

#--------------------


# Grid search

control <- trainControl(method = 'repeatedcv',

            number = 10,

             repeats = 3,

             search = 'grid')

set.seed(seed)

tunegrid <- expand.grid(.mtry=c(1:80))

mtry <- sqrt(ncol(x))

rf_gridsearch <- train(~.,

            data = dataTrain[1:200,],

            method = 'rf',

             metric = 0,

            tuneGrid = tunegrid,
```

```r
            trControl = control)

print(rf_gridsearch)

plot(rf_gridsearch)

# make predictions

predictions<- predict(rf_gridsearch,dataTest)


# append predictions

pred<- cbind(dataTest,predictions)


# summarize results

confusionMatrix<- confusionMatrix(pred$predictions,pred$pitch_belt)

confusionMatrix

varImp(rf_gridsearch)


--------------------------

  # Boosting

  # -------------------------------------

# Boosting model requires three things


#1- a loss function to be optimized

#2- a weak learner to make predictions

#3- an additive model to add the weak learners to minimize the loss function


# gradient boosting

control <- trainControl(method = 'repeatedcv',
```

```r
            number = 5,

            repeats = 3,

            search = 'grid')


seed <- 7

library(C50)

set.seed(seed)

metric <- 'Accuracy'

gbm_mod <- train(pitch_belt~.,

        data = dataTrain,

        method = 'gbm',

        metric = 0,

        trControl = control)

print(gbm_mod)

plot(gbm_mod)


summary(gbm_mod)
# make predictions

predictions<- predict(gbm_mod,dataTest)


# append predictions

pred<- cbind(dataTest,predictions)


# summarize results

confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)
```

```
> setwd("C:/Users/Seshan/Desktop")
> library(readr)
> Weight_lift <- read.csv("Weight lift.csv")
> View(Weight_lift)
> str(Weight_lift)
'data.frame':   4024 obs. of  158 variables:
 $ user_name              : Factor w/ 5 levels "adelmo","carlitos",..: 3 3 3
3 3 3 3 3 3 3 ...
 $ raw_timestamp_part_1   : int  1322489729 1322489729 1322489729 1322489729
1322489729 1322489729 1322489729 1322489729 1322489729 1322489729 ...
 $ raw_timestamp_part_2   : int  34670 62641 70653 82654 90637 170626 190665
242723 267551 274689 ...
 $ cvtd_timestamp         : Factor w/ 7 levels "2/12/2011 13:35",..: 2 2 2 2
2 2 2 2 2 2 ...
 $ new_window             : Factor w/ 2 levels "no","yes": 1 1 1 1 1 1 1 1 1
1 ...
 $ num_window             : int  1 1 1 1 1 1 1 1 1 1 ...
 $ roll_belt              : num  3.7 3.66 3.58 3.56 3.57 3.45 3.31 2.91 2.31
2 ...
 $ pitch_belt             : num  41.6 42.8 43.7 44.4 45.1 45.6 46.2 46.9 47.
4 47.7 ...
 $ yaw_belt               : num  -82.8 -82.5 -82.3 -82.1 -81.9 -81.9 -81.9 -
82.2 -82.6 -82.8 ...
 $ total_accel_belt       : int  3 2 1 1 1 1 3 4 2 3 ...
 $ kurtosis_roll_belt     : num  -1.04 -1.04 -1.04 -1.04 -1.04 ...
 $ kurtosis_picth_belt    : num  -0.391 -0.391 -0.391 -0.391 -0.391 ...
 $ skewness_roll_belt     : num  0.00541 0.00541 0.00541 0.00541 0.00541 ...
 $ skewness_roll_belt.1   : num  0.0451 0.0451 0.0451 0.0451 0.0451 ...
 $ max_roll_belt          : num  -4.1 -4.1 -4.1 -4.1 -4.1 -4.1 -4.1 -4.1 -4.
1 -4.1 ...
 $ max_picth_belt         : int  20 20 20 20 20 20 20 20 20 20 ...
 $ max_yaw_belt           : num  -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 ...
 $ min_roll_belt          : num  -7.25 -7.25 -7.25 -7.25 -7.25 -7.25 -7.25 -
7.25 -7.25 -7.25 ...
 $ min_pitch_belt         : int  18 18 18 18 18 18 18 18 18 18 ...
 $ min_yaw_belt           : num  -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 ...
 $ amplitude_roll_belt    : num  1.34 1.34 1.34 1.34 1.34 ...
 $ amplitude_pitch_belt   : int  2 2 2 2 2 2 2 2 2 2 ...
 $ amplitude_yaw_belt     : int  0 0 0 0 0 0 0 0 0 0 ...
 $ var_total_accel_belt   : num  0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 ...
 $ avg_roll_belt          : num  122 122 122 122 122 ...
 $ stddev_roll_belt       : num  0.6 0.6 0.6 0.6 0.6 0.6 0.6 0.6 0.6 0.6 ...
 $ var_roll_belt          : num  0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.3
5 0.35 ...
 $ avg_pitch_belt         : num  25.8 25.8 25.8 25.8 25.8 ...
 $ stddev_pitch_belt      : num  0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.3
5 0.35 ...
 $ var_pitch_belt         : num  0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 ...
 $ avg_yaw_belt           : num  -4.95 -4.95 -4.95 -4.95 -4.95 -4.95 -4.95 -
4.95 -4.95 -4.95 ...
 $ stddev_yaw_belt        : num  0.4 0.4 0.4 0.4 0.4 0.4 0.4 0.4 0.4 0.4 ...
```

```
 $ var_yaw_belt            : num  0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.1
7 0.17 ...
 $ gyros_belt_x            : num  2.02 1.96 1.88 1.8 1.77 1.75 1.78 1.75 1.65
1.48 ...
 $ gyros_belt_y            : num  0.18 0.14 0.08 0.03 0 -0.03 -0.06 -0.06 -0.
03 -0.06 ...
 $ gyros_belt_z            : num  0.02 0.05 0.05 0.08 0.13 0.16 0.15 0.23 0.3
3 0.21 ...
 $ accel_belt_x            : int  -3 -2 -2 -6 -4 1 1 2 -1 -18 ...
 $ accel_belt_y            : int  -18 -13 -6 -5 -9 -9 -24 -36 -19 18 ...
 $ accel_belt_z            : int  22 16 8 7 0 -5 -8 -9 -7 1 ...
 $ magnet_belt_x           : int  387 405 409 422 418 432 438 440 443 449 ...
 $ magnet_belt_y           : int  525 512 511 513 508 510 508 503 507 499 ...
 $ magnet_belt_z           : int  -267 -254 -244 -221 -208 -189 -176 -163 -14
0 -132 ...
 $ roll_arm                : num  132 129 125 120 115 110 104 98.6 93.2 88.5
...
 $ pitch_arm               : num  -43.7 -45.3 -46.8 -48.1 -49.1 -49.6 -49.9 -
49.7 -49 -48.1 ...
 $ yaw_arm                 : num  -53.6 -49 -43.7 -38.1 -31.7 -25.8 -18.5 -11
.4 -4.49 1.82 ...
 $ total_accel_arm         : int  38 38 35 35 34 33 29 28 27 22 ...
 $ var_accel_arm           : num  65.1 65.1 65.1 65.1 65.1 ...
 $ avg_roll_arm            : num  76.2 76.2 76.2 76.2 76.2 ...
 $ stddev_roll_arm         : num  16.1 16.1 16.1 16.1 16.1 ...
 $ var_roll_arm            : num  259 259 259 259 259 ...
 $ avg_pitch_arm           : num  -10.2 -10.2 -10.2 -10.2 -10.2 ...
 $ stddev_pitch_arm        : num  10.7 10.7 10.7 10.7 10.7 ...
 $ var_pitch_arm           : num  114 114 114 114 114 ...
 $ avg_yaw_arm             : num  19.1 19.1 19.1 19.1 19.1 ...
 $ stddev_yaw_arm          : num  35.9 35.9 35.9 35.9 35.9 ...
 $ var_yaw_arm             : num  1287 1287 1287 1287 1287 ...
 $ gyros_arm_x             : num  2.65 2.79 2.91 3.08 3.2 3.31 3.5 3.53 3.4 3
.48 ...
 $ gyros_arm_y             : num  -0.61 -0.64 -0.69 -0.72 -0.77 -0.83 -0.83 -
0.83 -0.83 -0.8 ...
 $ gyros_arm_z             : num  -0.02 -0.11 -0.15 -0.23 -0.25 -0.3 -0.31 -0
.21 -0.11 -0.15 ...
 $ accel_arm_x             : int  143 146 156 158 163 160 165 153 143 135 ...
 $ accel_arm_y             : int  30 35 44 52 55 59 67 70 78 96 ...
 $ accel_arm_z             : int  -346 -339 -307 -305 -288 -274 -225 -218 -20
5 -134 ...
 $ magnet_arm_x            : int  556 599 613 646 670 696 721 725 740 741 ...
 $ magnet_arm_y            : int  -205 -206 -198 -186 -175 -174 -161 -152 -13
3 -115 ...
 $ magnet_arm_z            : int  -374 -335 -319 -268 -241 -193 -121 -105 -43
14 ...
 $ kurtosis_roll_arm       : num  -1.18 -1.18 -1.18 -1.18 -1.18 ...
 $ kurtosis_picth_arm      : num  -0.969 -0.969 -0.969 -0.969 -0.969 ...
 $ kurtosis_yaw_arm        : num  -0.87 -0.87 -0.87 -0.87 -0.87 ...
 $ skewness_roll_arm       : num  0.124 0.124 0.124 0.124 0.124 ...
 $ skewness_pitch_arm      : num  -0.103 -0.103 -0.103 -0.103 -0.103 ...
 $ skewness_yaw_arm        : num  0.0598 0.0598 0.0598 0.0598 0.0598 ...
 $ max_roll_arm            : num  8.45 8.45 8.45 8.45 8.45 8.45 8.45 8.45 8.4
5 8.45 ...
 $ max_picth_arm           : num  77.2 77.2 77.2 77.2 77.2 ...
 $ max_yaw_arm             : int  38 38 38 38 38 38 38 38 38 38 ...
```

```
 $ min_roll_arm           : num  -33.6 -33.6 -33.6 -33.6 -33.6 -33.6 -33.6 -
33.6 -33.6 -33.6 ...
 $ min_pitch_arm          : num  -58.6 -58.6 -58.6 -58.6 -58.6 -58.6 -58.6 -
58.6 -58.6 -58.6 ...
 $ min_yaw_arm            : int  10 10 10 10 10 10 10 10 10 10 ...
 $ amplitude_roll_arm     : num  36.9 36.9 36.9 36.9 36.9 ...
 $ amplitude_pitch_arm    : num  122 122 122 122 122 ...
 $ amplitude_yaw_arm      : int  27 27 27 27 27 27 27 27 27 27 ...
 $ roll_dumbbell          : num  51.2 55.8 55.5 55.9 55.2 ...
 $ pitch_dumbbell         : num  11.7 9.65 6.88 11.08 11.43 ...
 $ yaw_dumbbell           : num  104.3 100.2 101.1 99.8 100.4 ...
 $ kurtosis_roll_dumbbell : num  -0.0959 -0.0959 -0.0959 -0.0959 -0.0959 ...
 $ kurtosis_picth_dumbbell : num  -0.442 -0.442 -0.442 -0.442 -0.442 ...
 $ skewness_roll_dumbbell : num  0.0819 0.0819 0.0819 0.0819 0.0819 0.0819 0
.0819 0.0819 0.0819 0.0819 ...
 $ skewness_pitch_dumbbell : num  -0.216 -0.216 -0.216 -0.216 -0.216 -0.216 -
0.216 -0.216 -0.216 -0.216 ...
 $ max_roll_dumbbell      : num  41.9 41.9 41.9 41.9 41.9 ...
 $ max_picth_dumbbell     : num  133 133 133 133 133 133 133 133 133 133 ...
 $ max_yaw_dumbbell       : num  -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.
1 -0.1 ...
 $ min_roll_dumbbell      : num  -26.8 -26.8 -26.8 -26.8 -26.8 ...
 $ min_pitch_dumbbell     : num  20.2 20.2 20.2 20.2 20.2 20.2 20.2 20.2 20.
2 20.2 ...
 $ min_yaw_dumbbell       : num  -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.
1 -0.1 ...
 $ amplitude_roll_dumbbell : num  55.7 55.7 55.7 55.7 55.7 ...
 $ amplitude_pitch_dumbbell: num  54.7 54.7 54.7 54.7 54.7 ...
 $ amplitude_yaw_dumbbell  : int  0 0 0 0 0 0 0 0 0 0 ...
 $ total_accel_dumbbell    : int  4 4 4 5 4 4 4 4 4 4 ...
 $ var_accel_dumbbell      : num  2.42 2.42 2.42 2.42 2.42 ...
 $ avg_roll_dumbbell       : num  -5.12 -5.12 -5.12 -5.12 -5.12 ...
  [list output truncated]
> data<-Weight_lift
> # load libraries
> library(caret)
> library(randomForest)
> library(rpart)
> library(rpart.plot)
> library(ggplot2)
> library(lattice)
> library(rattle)
>
> library(C50)
> #install.package('devtools') # Only needed if you dont have this installed.
> library(devtools)
> install_github('adam-m-mcelhinney/helpRFunctions')
Skipping install of 'helpRFunctions' from a github remote, the SHA1 (9eb16e8c
) has not changed since last install.
  Use `force = TRUE` to force installation
> library(helpRFunctions)
> names(data)
  [1] "user_name"                "raw_timestamp_part_1"       "raw_timestamp_pa
rt_2"
  [4] "cvtd_timestamp"           "new_window"                 "num_window"
  [7] "roll_belt"                "pitch_belt"                 "yaw_belt"
```

```
 [10] "total_accel_belt"          "kurtosis_roll_belt"          "kurtosis_picth_b
elt"
 [13] "skewness_roll_belt"         "skewness_roll_belt.1"        "max_roll_belt"
 [16] "max_picth_belt"             "max_yaw_belt"                "min_roll_belt"
 [19] "min_pitch_belt"             "min_yaw_belt"                "amplitude_roll_b
elt"
 [22] "amplitude_pitch_belt"       "amplitude_yaw_belt"          "var_total_accel_
belt"
 [25] "avg_roll_belt"              "stddev_roll_belt"            "var_roll_belt"
 [28] "avg_pitch_belt"             "stddev_pitch_belt"           "var_pitch_belt"
 [31] "avg_yaw_belt"               "stddev_yaw_belt"             "var_yaw_belt"
 [34] "gyros_belt_x"               "gyros_belt_y"                "gyros_belt_z"
 [37] "accel_belt_x"               "accel_belt_y"                "accel_belt_z"
 [40] "magnet_belt_x"              "magnet_belt_y"               "magnet_belt_z"
 [43] "roll_arm"                   "pitch_arm"                   "yaw_arm"
 [46] "total_accel_arm"            "var_accel_arm"               "avg_roll_arm"
 [49] "stddev_roll_arm"            "var_roll_arm"                "avg_pitch_arm"
 [52] "stddev_pitch_arm"           "var_pitch_arm"               "avg_yaw_arm"
 [55] "stddev_yaw_arm"             "var_yaw_arm"                 "gyros_arm_x"
 [58] "gyros_arm_y"                "gyros_arm_z"                 "accel_arm_x"
 [61] "accel_arm_y"                "accel_arm_z"                 "magnet_arm_x"
 [64] "magnet_arm_y"               "magnet_arm_z"                "kurtosis_roll_ar
m"
 [67] "kurtosis_picth_arm"         "kurtosis_yaw_arm"            "skewness_roll_ar
m"
 [70] "skewness_pitch_arm"         "skewness_yaw_arm"            "max_roll_arm"
 [73] "max_picth_arm"              "max_yaw_arm"                 "min_roll_arm"
 [76] "min_pitch_arm"              "min_yaw_arm"                 "amplitude_roll_a
rm"
 [79] "amplitude_pitch_arm"        "amplitude_yaw_arm"           "roll_dumbbell"
 [82] "pitch_dumbbell"             "yaw_dumbbell"                "kurtosis_roll_du
mbbell"
 [85] "kurtosis_picth_dumbbell"    "skewness_roll_dumbbell"      "skewness_pitch_d
umbbell"
 [88] "max_roll_dumbbell"          "max_picth_dumbbell"          "max_yaw_dumbbell
"
 [91] "min_roll_dumbbell"          "min_pitch_dumbbell"          "min_yaw_dumbbell
"
 [94] "amplitude_roll_dumbbell"    "amplitude_pitch_dumbbell"    "amplitude_yaw_du
mbbell"
 [97] "total_accel_dumbbell"       "var_accel_dumbbell"          "avg_roll_dumbbel
l"
[100] "stddev_roll_dumbbell"       "var_roll_dumbbell"           "avg_pitch_dumbbe
ll"
[103] "stddev_pitch_dumbbell"      "var_pitch_dumbbell"          "avg_yaw_dumbbell
"
[106] "stddev_yaw_dumbbell"        "var_yaw_dumbbell"            "gyros_dumbbell_x
"
[109] "gyros_dumbbell_y"           "gyros_dumbbell_z"            "accel_dumbbell_x
"
[112] "accel_dumbbell_y"           "accel_dumbbell_z"            "magnet_dumbbell_
x"
[115] "magnet_dumbbell_y"          "magnet_dumbbell_z"           "roll_forearm"
[118] "pitch_forearm"              "yaw_forearm"                 "kurtosis_roll_fo
rearm"
[121] "kurtosis_picth_forearm"     "skewness_roll_forearm"       "skewness_pitch_f
orearm"
```

```
[124] "max_roll_forearm"          "max_picth_forearm"          "max_yaw_forearm"
[127] "min_roll_forearm"          "min_pitch_forearm"          "min_yaw_forearm"
[130] "amplitude_roll_forearm"    "amplitude_pitch_forearm"    "amplitude_yaw_fo
rearm"
[133] "total_accel_forearm"       "var_accel_forearm"          "avg_roll_forearm
"
[136] "stddev_roll_forearm"       "var_roll_forearm"           "avg_pitch_forear
m"
[139] "stddev_pitch_forearm"      "var_pitch_forearm"          "avg_yaw_forearm"
[142] "stddev_yaw_forearm"        "var_yaw_forearm"            "gyros_forearm_x"
[145] "gyros_forearm_y"           "gyros_forearm_z"            "accel_forearm_x"
[148] "accel_forearm_y"           "accel_forearm_z"            "magnet_forearm_x
"
[151] "magnet_forearm_y"          "magnet_forearm_z"           "accel_forearm_y.
1"
[154] "accel_forearm_z.1"         "magnet_forearm_x.1"         "magnet_forearm_y
.1"
[157] "magnet_forearm_z.1"        "classe"
> dim(data)
[1] 4024  158
> pairs(data[1:10])
```

```
> # enable multi-core processing
> library(doParallel)
> cl <- makeCluster(detectCores())
> registerDoParallel()
> set.seed(12345)
> dataTrain<-data[1:4004,]
> dataTest<-data[4005:4024,]
> head(dataTrain)
  user_name raw_timestamp_part_1 raw_timestamp_part_2  cvtd_timestamp new_wi
ndow
1   eurico           1322489729                34670 28/11/2011 14:15
no
2   eurico           1322489729                62641 28/11/2011 14:15
no
3   eurico           1322489729                70653 28/11/2011 14:15
no
4   eurico           1322489729                82654 28/11/2011 14:15
no
5   eurico           1322489729                90637 28/11/2011 14:15
no
6   eurico           1322489729               170626 28/11/2011 14:15
no
  num_window roll_belt pitch_belt yaw_belt total_accel_belt kurtosis_roll_bel
t
1          1      3.70       41.6    -82.8                3           -1.0356
6
2          1      3.66       42.8    -82.5                2           -1.0356
6
3          1      3.58       43.7    -82.3                1           -1.0356
6
4          1      3.56       44.4    -82.1                1           -1.0356
6
5          1      3.57       45.1    -81.9                1           -1.0356
6
```

```
6          1      3.45      45.6     -81.9                  1          -1.0356
6
```

	kurtosis_picth_belt	skewness_roll_belt	skewness_roll_belt.1	max_roll_belt
1	-0.39133	0.005406	0.045115	-4.1
2	-0.39133	0.005406	0.045115	-4.1
3	-0.39133	0.005406	0.045115	-4.1
4	-0.39133	0.005406	0.045115	-4.1
5	-0.39133	0.005406	0.045115	-4.1
6	-0.39133	0.005406	0.045115	-4.1

	max_picth_belt	max_yaw_belt	min_roll_belt	min_pitch_belt	min_yaw_belt
1	20	-1	-7.25	18	-1
2	20	-1	-7.25	18	-1
3	20	-1	-7.25	18	-1
4	20	-1	-7.25	18	-1
5	20	-1	-7.25	18	-1
6	20	-1	-7.25	18	-1

	amplitude_roll_belt	amplitude_pitch_belt	amplitude_yaw_belt	var_total_accel_belt
1	1.345	2	0	0.3
2	1.345	2	0	0.3
3	1.345	2	0	0.3
4	1.345	2	0	0.3
5	1.345	2	0	0.3
6	1.345	2	0	0.3

	avg_roll_belt	stddev_roll_belt	var_roll_belt	avg_pitch_belt	stddev_pitch_belt
1	121.9	0.6	0.35	25.75	0.35
2	121.9	0.6	0.35	25.75	0.35
3	121.9	0.6	0.35	25.75	0.35
4	121.9	0.6	0.35	25.75	0.35
5	121.9	0.6	0.35	25.75	0.35
6	121.9	0.6	0.35	25.75	0.35

	var_pitch_belt	avg_yaw_belt	stddev_yaw_belt	var_yaw_belt	gyros_belt_x	gyros_belt_y
1	0.1	-4.95	0.4	0.17	2.02	0.18
2	0.1	-4.95	0.4	0.17	1.96	0.14
3	0.1	-4.95	0.4	0.17	1.88	0.08
4	0.1	-4.95	0.4	0.17	1.80	0.03
5	0.1	-4.95	0.4	0.17	1.77	0.00

6	0.1	-4.95	0.4	0.17	1.75	-0.03

	gyros_belt_z	accel_belt_x	accel_belt_y	accel_belt_z	magnet_belt_x	magnet_belt_y
1	0.02	-3	-18	22	387	525
2	0.05	-2	-13	16	405	512
3	0.05	-2	-6	8	409	511
4	0.08	-6	-5	7	422	513
5	0.13	-4	-9	0	418	508
6	0.16	1	-9	-5	432	510

	magnet_belt_z	roll_arm	pitch_arm	yaw_arm	total_accel_arm	var_accel_arm	avg_roll_arm
1	-267	132	-43.7	-53.6	38	65.0977	76.22175
2	-254	129	-45.3	-49.0	38	65.0977	76.22175
3	-244	125	-46.8	-43.7	35	65.0977	76.22175
4	-221	120	-48.1	-38.1	35	65.0977	76.22175
5	-208	115	-49.1	-31.7	34	65.0977	76.22175
6	-189	110	-49.6	-25.8	33	65.0977	76.22175

	stddev_roll_arm	var_roll_arm	avg_pitch_arm	stddev_pitch_arm	var_pitch_arm
1	16.1039	259.3599	-10.1695	10.66725	113.7978
2	16.1039	259.3599	-10.1695	10.66725	113.7978
3	16.1039	259.3599	-10.1695	10.66725	113.7978
4	16.1039	259.3599	-10.1695	10.66725	113.7978
5	16.1039	259.3599	-10.1695	10.66725	113.7978
6	16.1039	259.3599	-10.1695	10.66725	113.7978

	avg_yaw_arm	stddev_yaw_arm	var_yaw_arm	gyros_arm_x	gyros_arm_y	gyros_arm_z
1	19.0615	35.8809	1287.463	2.65	-0.61	-0.02
2	19.0615	35.8809	1287.463	2.79	-0.64	-0.11
3	19.0615	35.8809	1287.463	2.91	-0.69	-0.15
4	19.0615	35.8809	1287.463	3.08	-0.72	-0.23
5	19.0615	35.8809	1287.463	3.20	-0.77	-0.25
6	19.0615	35.8809	1287.463	3.31	-0.83	-0.30

	accel_arm_x	accel_arm_y	accel_arm_z	magnet_arm_x	magnet_arm_y	magnet_arm_z
1	143	30	-346	556	-205	-374
2	146	35	-339	599	-206	-335
3	156	44	-307	613	-198	-319
4	158	52	-305	646	-186	-268
5	163	55	-288	670	-175	-241
6	160	59	-274	696	-174	-193

	kurtosis_roll_arm	kurtosis_picth_arm	kurtosis_yaw_arm	skewness_roll_arm
1	-1.18224	-0.96912	-0.86977	0.12353
2	-1.18224	-0.96912	-0.86977	0.12353
3	-1.18224	-0.96912	-0.86977	0.12353
4	-1.18224	-0.96912	-0.86977	0.12353
5	-1.18224	-0.96912	-0.86977	0.12353

	skewness_pitch_arm	skewness_yaw_arm	max_roll_arm	max_picth_arm	max_yaw_arm
6	-1.18224	-0.96912	-0.86977	0.12353	
1	-0.10319	0.059765	8.45	77.25	38
2	-0.10319	0.059765	8.45	77.25	38
3	-0.10319	0.059765	8.45	77.25	38
4	-0.10319	0.059765	8.45	77.25	38
5	-0.10319	0.059765	8.45	77.25	38
6	-0.10319	0.059765	8.45	77.25	38

	min_roll_arm	min_pitch_arm	min_yaw_arm	amplitude_roll_arm	amplitude_pitch_arm
1	-33.6	-58.6	10	36.945	121.5
2	-33.6	-58.6	10	36.945	121.5
3	-33.6	-58.6	10	36.945	121.5
4	-33.6	-58.6	10	36.945	121.5
5	-33.6	-58.6	10	36.945	121.5
6	-33.6	-58.6	10	36.945	121.5

	amplitude_yaw_arm	roll_dumbbell	pitch_dumbbell	yaw_dumbbell	kurtosis_roll_dumbbell
1	27	51.23554	11.698847	104.26473	-0.09595
2	27	55.82442	9.645819	100.22805	-0.09595
3	27	55.46983	6.875244	101.08411	-0.09595
4	27	55.94486	11.079297	99.78456	-0.09595
5	27	55.21174	11.426833	100.42258	-0.09595
6	27	54.24731	14.126636	100.61574	-0.09595

	kurtosis_picth_dumbbell	skewness_roll_dumbbell	skewness_pitch_dumbbell
1	-0.4422	0.0819	-0.216
2	-0.4422	0.0819	-0.216
3	-0.4422	0.0819	-0.216
4	-0.4422	0.0819	-0.216
5	-0.4422	0.0819	-0.216
6	-0.4422	0.0819	-0.216

	max_roll_dumbbell	max_picth_dumbbell	max_yaw_dumbbell	min_roll_dumbbell
1	41.85	133	-0.1	-26.75
2	41.85	133	-0.1	-26.75
3	41.85	133	-0.1	-26.75
4	41.85	133	-0.1	-26.75
5	41.85	133	-0.1	-26.75
6	41.85	133	-0.1	-26.75

	min_pitch_dumbbell	min_yaw_dumbbell	amplitude_roll_dumbbell	amplitude_pitch_dumbbell
1	20.2	-0.1	55.71	54.74
2	20.2	-0.1	55.71	54.74

3	20.2	-0.1	55.71	54.74
4	20.2	-0.1	55.71	54.74
5	20.2	-0.1	55.71	54.74
6	20.2	-0.1	55.71	54.74

	amplitude_yaw_dumbbell	total_accel_dumbbell	var_accel_dumbbell	avg_roll_dumbbell
1	0	4	2.41635	-5.11805
2	0	4	2.41635	-5.11805
3	0	4	2.41635	-5.11805
4	0	5	2.41635	-5.11805
5	0	4	2.41635	-5.11805
6	0	4	2.41635	-5.11805

	stddev_roll_dumbbell	var_roll_dumbbell	avg_pitch_dumbbell	stddev_pitch_dumbbell
1	17.058	291.001	13.9312	14.1062
2	17.058	291.001	13.9312	14.1062
3	17.058	291.001	13.9312	14.1062
4	17.058	291.001	13.9312	14.1062
5	17.058	291.001	13.9312	14.1062
6	17.058	291.001	13.9312	14.1062

	var_pitch_dumbbell	avg_yaw_dumbbell	stddev_yaw_dumbbell	var_yaw_dumbbell
1	199.0775	64.7063	13.5747	184.5578
2	199.0775	64.7063	13.5747	184.5578
3	199.0775	64.7063	13.5747	184.5578
4	199.0775	64.7063	13.5747	184.5578
5	199.0775	64.7063	13.5747	184.5578
6	199.0775	64.7063	13.5747	184.5578

	gyros_dumbbell_x	gyros_dumbbell_y	gyros_dumbbell_z	accel_dumbbell_x	accel_dumbbell_y
1	-0.31	0.16	0.08	5	21
2	-0.31	0.14	0.07	4	22
3	-0.31	0.16	0.05	3	23
4	-0.31	0.16	0.07	5	24
5	-0.31	0.14	0.07	5	23
6	-0.31	0.14	0.07	6	22

```
  accel_dumbbell_z magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z roll
_forearm
1                37              -471               191               277
-111
2                35              -472               184               281
-112
3                37              -468               190               275
-114
4                38              -469               184               285
-115
5                37              -468               189               292
-117
6                36              -473               188               278
-118
  pitch_forearm yaw_forearm kurtosis_roll_forearm kurtosis_picth_forearm
1          26.5         138              -1.09475               -0.97525
2          26.2         138              -1.09475               -0.97525
3          26.0         137              -1.09475               -0.97525
4          25.8         137              -1.09475               -0.97525
5          25.5         137              -1.09475               -0.97525
6          25.1         137              -1.09475               -0.97525
  skewness_roll_forearm skewness_pitch_forearm max_roll_forearm max_picth_for
earm
1              -0.05065                0.17285             49.6
168
2              -0.05065                0.17285             49.6
168
3              -0.05065                0.17285             49.6
168
4              -0.05065                0.17285             49.6
168
5              -0.05065                0.17285             49.6
168
6              -0.05065                0.17285             49.6
168
  max_yaw_forearm min_roll_forearm min_pitch_forearm min_yaw_forearm
1            -1.1             4.65            -168.5            -1.1
2            -1.1             4.65            -168.5            -1.1
3            -1.1             4.65            -168.5            -1.1
4            -1.1             4.65            -168.5            -1.1
5            -1.1             4.65            -168.5            -1.1
6            -1.1             4.65            -168.5            -1.1
  amplitude_roll_forearm amplitude_pitch_forearm amplitude_yaw_forearm
1                   32.2                   341.5                     0
2                   32.2                   341.5                     0
3                   32.2                   341.5                     0
4                   32.2                   341.5                     0
5                   32.2                   341.5                     0
6                   32.2                   341.5                     0
  total_accel_forearm var_accel_forearm avg_roll_forearm stddev_roll_forearm
1                  30           14.0772         27.85936            45.16342
2                  31           14.0772         27.85936            45.16342
3                  32           14.0772         27.85936            45.16342
4                  33           14.0772         27.85936            45.16342
5                  34           14.0772         27.85936            45.16342
6                  36           14.0772         27.85936            45.16342
  var_roll_forearm avg_pitch_forearm stddev_pitch_forearm var_pitch_forearm
```

1	2749.163	25.35597	8.906695	79.33451
2	2749.163	25.35597	8.906695	79.33451
3	2749.163	25.35597	8.906695	79.33451
4	2749.163	25.35597	8.906695	79.33451
5	2749.163	25.35597	8.906695	79.33451
6	2749.163	25.35597	8.906695	79.33451

	avg_yaw_forearm	stddev_yaw_forearm	var_yaw_forearm	gyros_forearm_x	gyros_forearm_y
1	17.09505	74.27584	5541.956	-0.05	-0.37
2	17.09505	74.27584	5541.956	-0.06	-0.37
3	17.09505	74.27584	5541.956	-0.05	-0.27
4	17.09505	74.27584	5541.956	0.02	-0.24
5	17.09505	74.27584	5541.956	0.08	-0.27
6	17.09505	74.27584	5541.956	0.14	-0.29

	gyros_forearm_z	accel_forearm_x	accel_forearm_y	accel_forearm_z	magnet_forearm_x
1	-0.43	-170	155	184	-1160
2	-0.59	-178	164	182	-1150
3	-0.72	-182	172	185	-1130
4	-0.79	-185	182	188	-1120
5	-0.82	-188	195	188	-1100
6	-0.82	-208	207	190	-1090

	magnet_forearm_y	magnet_forearm_z	accel_forearm_y.1	accel_forearm_z.1
1	1400	-876	155	184
2	1410	-871	164	182
3	1400	-863	172	185
4	1400	-855	182	188
5	1400	-843	195	188
6	1400	-838	207	190

	magnet_forearm_x.1	magnet_forearm_y.1	magnet_forearm_z.1	classe
1	-1160	1400	-876	E
2	-1150	1410	-871	E
3	-1130	1400	-863	E
4	-1120	1400	-855	E
5	-1100	1400	-843	E
6	-1090	1400	-838	E

```
> head(dataTest)
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	user_name	raw_timestamp_part_1	raw_timestamp_part_2	cvtd_timestamp	new_window
4005	pedro	1323095020	504350	5/12/2011 14:23	no
4006	pedro	1323095020	504423	5/12/2011 14:23	no
4007	pedro	1323095020	504460	5/12/2011 14:23	no

4008	pedro	1323095020	532277 5/12/2011 14:23	no
4009	pedro	1323095020	532302 5/12/2011 14:23	no
4010	pedro	1323095020	572363 5/12/2011 14:23	no

	num_window	roll_belt	pitch_belt	yaw_belt	total_accel_belt	kurtosis_roll_belt
4005	91	122	25.9	-3.54	19	-1.03566
4006	91	122	25.9	-3.48	19	-1.03566
4007	91	122	25.8	-3.39	19	-1.03566
4008	91	122	25.8	-3.33	19	-1.03566
4009	91	122	25.8	-3.30	19	-1.03566
4010	91	122	25.8	-3.29	19	-1.03566

	kurtosis_picth_belt	skewness_roll_belt	skewness_roll_belt.1	max_roll_belt
4005	-0.39133	0.005406	0.045115	-4.1
4006	-0.39133	0.005406	0.045115	-4.1
4007	-0.39133	0.005406	0.045115	-4.1
4008	-0.39133	0.005406	0.045115	-4.1
4009	-0.39133	0.005406	0.045115	-4.1
4010	-0.39133	0.005406	0.045115	-4.1

	max_picth_belt	max_yaw_belt	min_roll_belt	min_pitch_belt	min_yaw_belt
4005	20	-1	-7.25	18	-1
4006	20	-1	-7.25	18	-1
4007	20	-1	-7.25	18	-1
4008	20	-1	-7.25	18	-1
4009	20	-1	-7.25	18	-1
4010	20	-1	-7.25	18	-1

	amplitude_roll_belt	amplitude_pitch_belt	amplitude_yaw_belt	var_total_accel_belt
4005	1.345	2	0	0.3
4006	1.345	2	0	0.3
4007	1.345	2	0	0.3
4008	1.345	2	0	0.3
4009	1.345	2	0	0.3
4010	1.345	2	0	0.3

	avg_roll_belt	stddev_roll_belt	var_roll_belt	avg_pitch_belt	stddev_pitch_belt

4005	121.9	0.6	0.35	25.75	
0.35					
4006	121.9	0.6	0.35	25.75	
0.35					
4007	121.9	0.6	0.35	25.75	
0.35					
4008	121.9	0.6	0.35	25.75	
0.35					
4009	121.9	0.6	0.35	25.75	
0.35					
4010	121.9	0.6	0.35	25.75	
0.35					

	var_pitch_belt	avg_yaw_belt	stddev_yaw_belt	var_yaw_belt	gyros_belt_x
4005	0.1	-4.95	0.4	0.17	-0.39
4006	0.1	-4.95	0.4	0.17	-0.39
4007	0.1	-4.95	0.4	0.17	-0.37
4008	0.1	-4.95	0.4	0.17	-0.39
4009	0.1	-4.95	0.4	0.17	-0.39
4010	0.1	-4.95	0.4	0.17	-0.40

	gyros_belt_y	gyros_belt_z	accel_belt_x	accel_belt_y	accel_belt_z	magnet_belt_x
4005	-0.03	-0.48	-39	71	-170	-1
4006	-0.03	-0.46	-39	69	-172	1
4007	-0.03	-0.46	-40	68	-170	-4
4008	-0.03	-0.46	-42	69	-167	-6
4009	-0.03	-0.46	-42	70	-168	-6
4010	-0.03	-0.46	-42	72	-171	-4

	magnet_belt_y	magnet_belt_z	roll_arm	pitch_arm	yaw_arm	total_accel_arm
4005	582	-356	83.0	23.1	47.1	23
4006	587	-358	81.6	22.1	44.5	25
4007	586	-362	80.2	21.0	41.9	24
4008	589	-366	78.9	20.0	39.4	26
4009	590	-368	77.6	18.9	36.7	27
4010	591	-354	76.5	17.7	34.0	28

	var_accel_arm	avg_roll_arm	stddev_roll_arm	var_roll_arm	avg_pitch_arm
4005	65.0977	76.22175	16.1039	259.3599	-10.1695
4006	65.0977	76.22175	16.1039	259.3599	-10.1695
4007	65.0977	76.22175	16.1039	259.3599	-10.1695
4008	65.0977	76.22175	16.1039	259.3599	-10.1695
4009	65.0977	76.22175	16.1039	259.3599	-10.1695
4010	65.0977	76.22175	16.1039	259.3599	-10.1695

	stddev_pitch_arm	var_pitch_arm	avg_yaw_arm	stddev_yaw_arm	var_yaw_arm	gyros_arm_x
4005	10.66725	113.7978	19.0615	35.8809	1287.463	-2.06
4006	10.66725	113.7978	19.0615	35.8809	1287.463	-2.06
4007	10.66725	113.7978	19.0615	35.8809	1287.463	-2.07
4008	10.66725	113.7978	19.0615	35.8809	1287.463	-2.14

4009	10.66725	113.7978	19.0615	35.8809	1287.463	-2.14
4010	10.66725	113.7978	19.0615	35.8809	1287.463	-2.12

	gyros_arm_y	gyros_arm_z	accel_arm_x	accel_arm_y	accel_arm_z	magnet_arm_x
4005	0.55	-0.26	182	28	138	342
4006	0.56	-0.31	196	23	148	370
4007	0.51	-0.33	193	18	140	388
4008	0.48	-0.31	207	21	140	432
4009	0.43	-0.28	226	12	140	448
4010	0.37	-0.20	235	9	143	482

	magnet_arm_y	magnet_arm_z	kurtosis_roll_arm	kurtosis_picth_arm	kurtosis_yaw_arm
4005	280	503	-1.18224	-0.96912	-0.86977
4006	263	485	-1.18224	-0.96912	-0.86977
4007	261	486	-1.18224	-0.96912	-0.86977
4008	249	472	-1.18224	-0.96912	-0.86977
4009	239	454	-1.18224	-0.96912	-0.86977
4010	225	437	-1.18224	-0.96912	-0.86977

	skewness_roll_arm	skewness_pitch_arm	skewness_yaw_arm	max_roll_arm	max_picth_arm
4005	0.12353	-0.10319	0.059765	8.45	77.25
4006	0.12353	-0.10319	0.059765	8.45	77.25
4007	0.12353	-0.10319	0.059765	8.45	77.25
4008	0.12353	-0.10319	0.059765	8.45	77.25
4009	0.12353	-0.10319	0.059765	8.45	77.25
4010	0.12353	-0.10319	0.059765	8.45	77.25

	max_yaw_arm	min_roll_arm	min_pitch_arm	min_yaw_arm	amplitude_roll_arm
4005	38	-33.6	-58.6	10	36.945
4006	38	-33.6	-58.6	10	36.945
4007	38	-33.6	-58.6	10	36.945
4008	38	-33.6	-58.6	10	36.945
4009	38	-33.6	-58.6	10	36.945
4010	38	-33.6	-58.6	10	36.945

	amplitude_pitch_arm	amplitude_yaw_arm	roll_dumbbell	pitch_dumbbell	yaw_dumbbell
4005	121.5	27	-64.335693	34.112879	81.36272
4006	121.5	27	-40.195925	53.186300	87.56417
4007	121.5	27	-2.792178	62.646067	94.35153
4008	121.5	27	10.384733	49.182165	106.61750

```
4009            121.5           27    16.647582    22.278218    12
9.09792
4010            121.5           27   -14.860425     6.172999    14
0.97044
```

	kurtosis_roll_dumbbell	kurtosis_picth_dumbbell	skewness_roll_dumbbell
4005	-0.09595	-0.4422	0.0819
4006	-0.09595	-0.4422	0.0819
4007	-0.09595	-0.4422	0.0819
4008	-0.09595	-0.4422	0.0819
4009	-0.09595	-0.4422	0.0819
4010	-0.09595	-0.4422	0.0819

	skewness_pitch_dumbbell	max_roll_dumbbell	max_picth_dumbbell	max_yaw_dumbbell
4005	-0.216	41.85	133	-0.1
4006	-0.216	41.85	133	-0.1
4007	-0.216	41.85	133	-0.1
4008	-0.216	41.85	133	-0.1
4009	-0.216	41.85	133	-0.1
4010	-0.216	41.85	133	-0.1

	min_roll_dumbbell	min_pitch_dumbbell	min_yaw_dumbbell	amplitude_roll_dumbbell
4005	-26.75	20.2	-0.1	55.71
4006	-26.75	20.2	-0.1	55.71
4007	-26.75	20.2	-0.1	55.71
4008	-26.75	20.2	-0.1	55.71
4009	-26.75	20.2	-0.1	55.71
4010	-26.75	20.2	-0.1	55.71

	amplitude_pitch_dumbbell	amplitude_yaw_dumbbell	total_accel_dumbbell
4005	54.74	0	9
4006	54.74	0	7
4007	54.74	0	7
4008	54.74	0	9
4009	54.74	0	9
4010	54.74	0	8

	var_accel_dumbbell	avg_roll_dumbbell	stddev_roll_dumbbell	var_roll_dumbbell
4005	2.41635	-5.11805	17.058	291.001
4006	2.41635	-5.11805	17.058	291.001
4007	2.41635	-5.11805	17.058	291.001
4008	2.41635	-5.11805	17.058	291.001

4009	2.41635	-5.11805	17.058	291.001
4010	2.41635	-5.11805	17.058	291.001

	avg_pitch_dumbbell	stddev_pitch_dumbbell	var_pitch_dumbbell	avg_yaw_dumbbell
4005	13.9312	14.1062	199.0775	64.7063
4006	13.9312	14.1062	199.0775	64.7063
4007	13.9312	14.1062	199.0775	64.7063
4008	13.9312	14.1062	199.0775	64.7063
4009	13.9312	14.1062	199.0775	64.7063
4010	13.9312	14.1062	199.0775	64.7063

	stddev_yaw_dumbbell	var_yaw_dumbbell	gyros_dumbbell_x	gyros_dumbbell_y
4005	13.5747	184.5578	0.16	-0.75
4006	13.5747	184.5578	0.08	-0.79
4007	13.5747	184.5578	0.03	-0.87
4008	13.5747	184.5578	-0.02	-0.92
4009	13.5747	184.5578	-0.02	-0.85
4010	13.5747	184.5578	0.00	-0.63

	gyros_dumbbell_z	accel_dumbbell_x	accel_dumbbell_y	accel_dumbbell_z
4005	0.39	29	-52	63
4006	0.15	35	-27	53
4007	-0.02	42	-2	58
4008	0.11	41	9	76
4009	0.33	20	15	87
4010	0.51	5	-12	80

	magnet_dumbbell_x	magnet_dumbbell_y	magnet_dumbbell_z	roll_forearm	pitch_forearm
4005	494	-550	-105	141	40.9
4006	501	-554	-91	142	38.1
4007	514	-539	-104	142	34.3
4008	515	-533	-108	142	31.4
4009	526	-525	-98	141	29.2
4010	537	-517	-108	141	27.0

	yaw_forearm	kurtosis_roll_forearm	kurtosis_picth_forearm	skewness_roll_forearm
4005	147	-1.09475	-0.97525	-0.05065
4006	143	-1.09475	-0.97525	-0.05065
4007	137	-1.09475	-0.97525	-0.05065
4008	132	-1.09475	-0.97525	-0.05065

```
4009        128            -1.09475              -0.97525               -0
.05065
4010        123            -1.09475              -0.97525               -0
.05065
     skewness_pitch_forearm max_roll_forearm max_picth_forearm max_yaw_forear
m
4005                0.17285             49.6               168              -1.
1
4006                0.17285             49.6               168              -1.
1
4007                0.17285             49.6               168              -1.
1
4008                0.17285             49.6               168              -1.
1
4009                0.17285             49.6               168              -1.
1
4010                0.17285             49.6               168              -1.
1
     min_roll_forearm min_pitch_forearm min_yaw_forearm amplitude_roll_forear
m
4005             4.65            -168.5            -1.1                     32.
2
4006             4.65            -168.5            -1.1                     32.
2
4007             4.65            -168.5            -1.1                     32.
2
4008             4.65            -168.5            -1.1                     32.
2
4009             4.65            -168.5            -1.1                     32.
2
4010             4.65            -168.5            -1.1                     32.
2
     amplitude_pitch_forearm amplitude_yaw_forearm total_accel_forearm
4005                   341.5                     0                  29
4006                   341.5                     0                  40
4007                   341.5                     0                  39
4008                   341.5                     0                  39
4009                   341.5                     0                  39
4010                   341.5                     0                  38
     var_accel_forearm avg_roll_forearm stddev_roll_forearm var_roll_forearm
4005          14.0772         27.85936            45.16342         2749.163
4006          14.0772         27.85936            45.16342         2749.163
4007          14.0772         27.85936            45.16342         2749.163
4008          14.0772         27.85936            45.16342         2749.163
4009          14.0772         27.85936            45.16342         2749.163
4010          14.0772         27.85936            45.16342         2749.163
     avg_pitch_forearm stddev_pitch_forearm var_pitch_forearm avg_yaw_forearm
4005          25.35597             8.906695          79.33451         17.09505
4006          25.35597             8.906695          79.33451         17.09505
4007          25.35597             8.906695          79.33451         17.09505
4008          25.35597             8.906695          79.33451         17.09505
4009          25.35597             8.906695          79.33451         17.09505
4010          25.35597             8.906695          79.33451         17.09505
     stddev_yaw_forearm var_yaw_forearm gyros_forearm_x gyros_forearm_y
4005           74.27584        5541.956            0.16            3.48
4006           74.27584        5541.956            0.11            3.36
4007           74.27584        5541.956            0.21            4.38
```

```
4008            74.27584          5541.956           0.02           3.77
4009            74.27584          5541.956          -0.35           3.21
4010            74.27584          5541.956          -0.69           3.58
     gyros_forearm_z accel_forearm_x accel_forearm_y accel_forearm_z magnet_f
orearm_x
4005            3.08              12              269              -98
-704
4006            2.76             -51              353             -158
-706
4007            2.03              33              357             -122
-700
4008            1.74               9              359             -125
-684
4009            1.44              -9              352             -143
-673
4010            1.07             -44              335             -153
-652
     magnet_forearm_y magnet_forearm_z accel_forearm_y.1 accel_forearm_z.1
4005              398              921              269               -98
4006              484              923              353              -158
4007              524              921              357              -122
4008              589              923              359              -125
4009              619              935              352              -143
4010              672              947              335              -153
     magnet_forearm_x.1 magnet_forearm_y.1 magnet_forearm_z.1 classe
4005             -704              398              921    C
4006             -706              484              923    C
4007             -700              524              921    C
4008             -684              589              923    C
4009             -673              619              935    C
4010             -652              672              947    C
```

```
> indexNA <- as.vector(sapply(dataTrain[,1:158],function(x) {length(which(is.
na(x)))!=0}))
> dataTrain <- dataTrain[,!indexNA]
> train_control<- trainControl(method="cv", number=10)
>
> model<- train(classe ~., data=dataTrain,trControl=train_control, method="rf
")
> model
Random Forest

4004 samples
 157 predictor
   5 classes: 'A', 'B', 'C', 'D', 'E'

No pre-processing
Resampling: Cross-Validated (10 fold)
Summary of sample sizes: 3604, 3604, 3604, 3604, 3603, 3603, ...
Resampling results across tuning parameters:

  mtry  Accuracy   Kappa
   2    0.9730274  0.9617679
  83    1.0000000  1.0000000
  165   0.9990006  0.9985890
```

```
Accuracy was used to select the optimal model using the largest value.
The final value used for the model was mtry = 83.
> # make predictions
> predictions<- predict(model,dataTrain)
> # append predictions
> pred<- cbind(dataTrain,predictions)
> # summarize results
> confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)
> confusionMatrix
Confusion Matrix and Statistics

          Reference
Prediction    A    B    C    D    E
        A 1365    0    0    0    0
        B    0  901    0    0    0
        C    0    0   92    0    0
        D    0    0    0  276    0
        E    0    0    0    0 1370

Overall Statistics

               Accuracy : 1
                 95% CI : (0.9991, 1)
    No Information Rate : 0.3422
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 1
 Mcnemar's Test P-Value : NA

Statistics by Class:

                     Class: A Class: B Class: C Class: D Class: E
Sensitivity            1.0000    1.000  1.00000  1.00000   1.0000
Specificity            1.0000    1.000  1.00000  1.00000   1.0000
Pos Pred Value         1.0000    1.000  1.00000  1.00000   1.0000
Neg Pred Value         1.0000    1.000  1.00000  1.00000   1.0000
Prevalence             0.3409    0.225  0.02298  0.06893   0.3422
Detection Rate         0.3409    0.225  0.02298  0.06893   0.3422
Detection Prevalence   0.3409    0.225  0.02298  0.06893   0.3422
Balanced Accuracy      1.0000    1.000  1.00000  1.00000   1.0000
> #how do we create a cross validation scheme
> control <- trainControl(method = 'repeatedcv',
+                         number = 10,
+                         repeats = 3)
> seed <-7
> metric <- 'Accuracy'
> set.seed(seed)
> mtry <- sqrt(ncol(dataTrain))
> tunegrid <- expand.grid(.mtry=mtry)
> rf_default <- train(pitch_belt~.,
+                     data = dataTrain,
+                     method = 'rf',
+                     metric = 0,
+                     tuneGrid = tunegrid,
+                     trControl = control)
Warning message:
In train.default(x, y, weights = w, ...) :
```

```
   The metric "0" was not in the result set. RMSE will be used instead.
> print(rf_default)
Random Forest

4004 samples
 157 predictor

No pre-processing
Resampling: Cross-Validated (10 fold, repeated 3 times)
Summary of sample sizes: 3602, 3603, 3603, 3603, 3605, 3604, ...
Resampling results:

  RMSE        Rsquared   MAE
  0.3719505   0.9996205   0.1836054

Tuning parameter 'mtry' was held constant at a value of 12.56981
> #------------------------------
>
> # make predictions
> predictions<- predict(rf_default,dataTest)
> # append predictions
> pred<- cbind(dataTest,predictions)
> # summarize results
> confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)
Error: `data` and `reference` should be factors with the same levels.
> confusionMatrix
Confusion Matrix and Statistics

          Reference
Prediction    A     B    C    D     E
        A 1365     0    0    0     0
        B    0   901    0    0     0
        C    0     0   92    0     0
        D    0     0    0  276     0
        E    0     0    0    0  1370

Overall Statistics

               Accuracy : 1
                 95% CI : (0.9991, 1)
    No Information Rate : 0.3422
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 1
 Mcnemar's Test P-Value : NA

Statistics by Class:

                     Class: A Class: B Class: C Class: D Class: E
Sensitivity            1.0000    1.000  1.00000  1.00000   1.0000
Specificity            1.0000    1.000  1.00000  1.00000   1.0000
Pos Pred Value         1.0000    1.000  1.00000  1.00000   1.0000
Neg Pred Value         1.0000    1.000  1.00000  1.00000   1.0000
Prevalence             0.3409    0.225  0.02298  0.06893   0.3422
Detection Rate         0.3409    0.225  0.02298  0.06893   0.3422
Detection Prevalence   0.3409    0.225  0.02298  0.06893   0.3422
Balanced Accuracy      1.0000    1.000  1.00000  1.00000   1.0000
```

```
> varImp(rf_default)
Error in varImp[, "%IncMSE"] : subscript out of bounds
Called from: data.frame(Overall = varImp[, "%IncMSE"])
Browse[1]> #----------------
Browse[1]> # random search for parameters
Browse[1]> control <- trainControl(method = 'repeatedcv',
+                            number = 10,
+                            repeats = 3,
+                            search = 'random')
Browse[1]> # make predictions
Browse[1]> predictions<- predict(rf_default,dataTest)
Browse[1]>
> # append predictions
> pred<- cbind(dataTest,predictions)
>
> # summarize results
> confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)
Error: `data` and `reference` should be factors with the same levels.
> confusionMatrix
Confusion Matrix and Statistics

          Reference
Prediction    A    B    C    D    E
         A 1365    0    0    0    0
         B    0  901    0    0    0
         C    0    0   92    0    0
         D    0    0    0  276    0
         E    0    0    0    0 1370

Overall Statistics

               Accuracy : 1
                 95% CI : (0.9991, 1)
    No Information Rate : 0.3422
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 1
 Mcnemar's Test P-Value : NA

Statistics by Class:

                     Class: A Class: B Class: C Class: D Class: E
Sensitivity            1.0000    1.000  1.00000  1.00000   1.0000
Specificity            1.0000    1.000  1.00000  1.00000   1.0000
Pos Pred Value         1.0000    1.000  1.00000  1.00000   1.0000
Neg Pred Value         1.0000    1.000  1.00000  1.00000   1.0000
Prevalence             0.3409    0.225  0.02298  0.06893   0.3422
Detection Rate         0.3409    0.225  0.02298  0.06893   0.3422
Detection Prevalence   0.3409    0.225  0.02298  0.06893   0.3422
Balanced Accuracy      1.0000    1.000  1.00000  1.00000   1.0000
> varImp(random)
Error in varImp(random) : object 'random' not found
> #--------------------
> #----------------------------------------------------------------
> # Grid search
> control <- trainControl(method = 'repeatedcv',
+                            number = 10,
```

```
+                       repeats = 3,
+                       search = 'grid')
> set.seed(seed)
> tunegrid <- expand.grid(.mtry=c(1:80))
> #mtry <- sqrt(ncol(x))
> rf_gridsearch <- train(~.,
+                    data = dataTrain[1:200,],
+                    method = 'rf',
+                    metric = metric,
+                    tuneGrid = tunegrid,
+                    trControl = control)
Error: Please make sure `y` is a factor or numeric value.
> print(rf_gridsearch)
Error in print(rf_gridsearch) : object 'rf_gridsearch' not found
> plot(rf_gridsearch)
Error in plot(rf_gridsearch) : object 'rf_gridsearch' not found
> # make predictions
> predictions<- predict(rf_gridsearch,dataTest)
Error in predict(rf_gridsearch, dataTest) :
  object 'rf_gridsearch' not found
>
> # append predictions
> pred<- cbind(dataTest,predictions)
>
> # summarize results
> confusionMatrix<- confusionMatrix(pred$predictions,pred$pitch_belt)
Error: `data` and `reference` should be factors with the same levels.
> confusionMatrix
Confusion Matrix and Statistics

          Reference
Prediction    A    B    C    D    E
        A 1365    0    0    0    0
        B    0  901    0    0    0
        C    0    0   92    0    0
        D    0    0    0  276    0
        E    0    0    0    0 1370

Overall Statistics

               Accuracy : 1
                 95% CI : (0.9991, 1)
    No Information Rate : 0.3422
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 1
 Mcnemar's Test P-Value : NA

Statistics by Class:

                     Class: A Class: B Class: C Class: D Class: E
Sensitivity            1.0000    1.000  1.00000  1.00000   1.0000
Specificity            1.0000    1.000  1.00000  1.00000   1.0000
Pos Pred Value         1.0000    1.000  1.00000  1.00000   1.0000
Neg Pred Value         1.0000    1.000  1.00000  1.00000   1.0000
Prevalence             0.3409    0.225  0.02298  0.06893   0.3422
Detection Rate         0.3409    0.225  0.02298  0.06893   0.3422
```

```
Detection Prevalence    0.3409    0.225   0.02298   0.06893    0.3422
Balanced Accuracy       1.0000    1.000   1.00000   1.00000    1.0000
> varImp(rf_gridsearch)
Error in varImp(rf_gridsearch) : object 'rf_gridsearch' not found
>
> ---------------------------
+   # Boosting
+   #  --------------------------------------
+ # Boosting model requires three things
+
+ #1- a loss function to be optimized
+ #2- a weak learner to make predictions
+ #3- an additive model to add the weak learners to minimize the loss functio
n
+
+ # gradient boosting
+ control <- trainControl(method = 'repeatedcv',
+                         number = 5,
+                         repeats = 3,
+                         search = 'grid')
Error in -`*tmp*` : invalid argument to unary operator
>
> seed <- 7
> library(C50)
> set.seed(seed)
> metric <- 'Accuracy'
> gbm_mod <- train(pitch_belt~.,
+                  data = dataTrain,
+                  method = 'gbm',
+                  metric = 0,
+                  trControl = control)
Iter   TrainDeviance   ValidDeviance   StepSize   Improve
     1     290.4643            nan     0.1000   66.8385
     2     240.0107            nan     0.1000   49.7536
     3     199.7165            nan     0.1000   39.9944
     4     166.7692            nan     0.1000   31.6237
     5     138.7180            nan     0.1000   27.8200
     6     117.1658            nan     0.1000   21.8218
     7      99.0041            nan     0.1000   17.7844
     8      84.2149            nan     0.1000   13.7951
     9      71.1916            nan     0.1000   12.5779
    10      60.7509            nan     0.1000   10.4406
    20      16.9581            nan     0.1000    2.0061
    40       4.0588            nan     0.1000    0.1219
    60       2.5921            nan     0.1000    0.0084
    80       2.1022            nan     0.1000   -0.0069
   100       1.7142            nan     0.1000   -0.0182
   120       1.5353            nan     0.1000   -0.0081
   140       1.2641            nan     0.1000    0.0052
   150       1.2063            nan     0.1000    0.0001

Warning messages:
1: In train.default(x, y, weights = w, ...) :
  The metric "0" was not in the result set. RMSE will be used instead.
2: In (function (x, y, offset = NULL, misc = NULL, distribution = "bernoulli"
, :
  variable 30: amplitude_yaw_belt has no variation.
```

```
3: In (function (x, y, offset = NULL, misc = NULL, distribution = "bernoulli"
, :
  variable 103: amplitude_yaw_dumbbell has no variation.
4: In (function (x, y, offset = NULL, misc = NULL, distribution = "bernoulli"
, :
  variable 139: amplitude_yaw_forearm has no variation.
> print(gbm_mod)
Stochastic Gradient Boosting

4004 samples
 157 predictor

No pre-processing
Resampling: Cross-Validated (10 fold, repeated 3 times)
Summary of sample sizes: 3602, 3603, 3603, 3603, 3605, 3604, ...
Resampling results across tuning parameters:

  interaction.depth  n.trees  RMSE      Rsquared   MAE
  1                   50      3.870491  0.9708972  2.0739488
  1                  100      2.518277  0.9818947  1.1065126
  1                  150      2.258849  0.9850289  0.9958785
  2                   50      2.183970  0.9866430  1.0364026
  2                  100      1.662759  0.9916854  0.8202113
  2                  150      1.485456  0.9934375  0.7464795
  3                   50      1.950370  0.9886048  0.9201246
  3                  100      1.529421  0.9928336  0.7607945
  3                  150      1.330676  0.9946265  0.6793264

Tuning parameter 'shrinkage' was held constant at a value of 0.1
Tuning
 parameter 'n.minobsinnode' was held constant at a value of 10
RMSE was used to select the optimal model using the smallest value.
The final values used for the model were n.trees = 150, interaction.depth =
 3, shrinkage = 0.1 and n.minobsinnode = 10.
> plot(gbm_mod)
>
> summary(gbm_mod)
                                                     var       rel.inf
accel_belt_x                                  accel_belt_x 5.294894e+01
user_namecarlitos                        user_namecarlitos 2.264130e+01
yaw_belt                                          yaw_belt 1.009582e+01
magnet_belt_z                                magnet_belt_z 3.195192e+00
roll_belt                                        roll_belt 2.097407e+00
magnet_belt_x                                magnet_belt_x 1.915681e+00
magnet_belt_y                                magnet_belt_y 1.262021e+00
user_nameeurico                            user_nameeurico 9.356612e-01
accel_forearm_z                            accel_forearm_z 8.031061e-01
yaw_dumbbell                                  yaw_dumbbell 6.542763e-01
magnet_dumbbell_z                        magnet_dumbbell_z 5.525906e-01
roll_arm                                          roll_arm 4.706543e-01
magnet_forearm_y                          magnet_forearm_y 4.194178e-01
raw_timestamp_part_1                  raw_timestamp_part_1 4.174086e-01
accel_dumbbell_y                          accel_dumbbell_y 3.929518e-01
total_accel_belt                          total_accel_belt 2.065530e-01
classeE                                            classeE 1.635014e-01
gyros_belt_x                                  gyros_belt_x 7.771816e-02
gyros_belt_z                                  gyros_belt_z 7.088366e-02
```

magnet_forearm_z	magnet_forearm_z	6.476310e-02
gyros_dumbbell_z	gyros_dumbbell_z	6.476114e-02
magnet_dumbbell_y	magnet_dumbbell_y	6.082279e-02
accel_arm_y	accel_arm_y	4.211095e-02
magnet_forearm_x	magnet_forearm_x	3.649721e-02
gyros_arm_x	gyros_arm_x	3.524758e-02
raw_timestamp_part_2	raw_timestamp_part_2	3.187452e-02
magnet_arm_y	magnet_arm_y	2.913115e-02
roll_forearm	roll_forearm	2.691063e-02
accel_belt_y	accel_belt_y	2.612166e-02
gyros_belt_y	gyros_belt_y	2.610858e-02
accel_forearm_x	accel_forearm_x	2.591538e-02
yaw_forearm	yaw_forearm	2.342590e-02
magnet_arm_x	magnet_arm_x	2.176473e-02
roll_dumbbell	roll_dumbbell	1.994693e-02
gyros_dumbbell_y	gyros_dumbbell_y	1.606333e-02
accel_dumbbell_z	accel_dumbbell_z	1.393099e-02
accel_arm_z	accel_arm_z	1.171088e-02
pitch_forearm	pitch_forearm	1.000282e-02
magnet_dumbbell_x	magnet_dumbbell_x	9.832274e-03
gyros_arm_z	gyros_arm_z	9.797342e-03
gyros_forearm_y	gyros_forearm_y	8.829820e-03
yaw_arm	yaw_arm	8.821700e-03
accel_belt_z	accel_belt_z	6.208694e-03
cvtd_timestamp5/12/2011 14:22	cvtd_timestamp5/12/2011 14:22	6.063530e-03
accel_dumbbell_x	accel_dumbbell_x	5.853397e-03
accel_arm_x	accel_arm_x	5.649238e-03
total_accel_dumbbell	total_accel_dumbbell	4.196944e-03
gyros_forearm_z	gyros_forearm_z	4.185309e-03
accel_forearm_y	accel_forearm_y	3.517185e-03
pitch_dumbbell	pitch_dumbbell	3.131461e-03
gyros_forearm_x	gyros_forearm_x	2.607342e-03
gyros_arm_y	gyros_arm_y	2.402347e-03
total_accel_arm	total_accel_arm	2.323679e-03
total_accel_forearm	total_accel_forearm	1.821801e-03
gyros_dumbbell_x	gyros_dumbbell_x	1.812110e-03
pitch_arm	pitch_arm	1.803214e-03
min_pitch_forearm	min_pitch_forearm	1.147246e-03
var_yaw_belt	var_yaw_belt	1.011198e-03
magnet_arm_z	magnet_arm_z	7.885704e-04
user_namejeremy	user_namejeremy	0.000000e+00
user_namepedro	user_namepedro	0.000000e+00
cvtd_timestamp28/11/2011 14:15	cvtd_timestamp28/11/2011 14:15	0.000000e+00
cvtd_timestamp30/11/2011 17:12	cvtd_timestamp30/11/2011 17:12	0.000000e+00
cvtd_timestamp5/12/2011 11:23	cvtd_timestamp5/12/2011 11:23	0.000000e+00
cvtd_timestamp5/12/2011 11:25	cvtd_timestamp5/12/2011 11:25	0.000000e+00
cvtd_timestamp5/12/2011 14:23	cvtd_timestamp5/12/2011 14:23	0.000000e+00
new_windowyes	new_windowyes	0.000000e+00
num_window	num_window	0.000000e+00
kurtosis_roll_belt	kurtosis_roll_belt	0.000000e+00
kurtosis_picth_belt	kurtosis_picth_belt	0.000000e+00
skewness_roll_belt	skewness_roll_belt	0.000000e+00
skewness_roll_belt.1	skewness_roll_belt.1	0.000000e+00
max_roll_belt	max_roll_belt	0.000000e+00
max_picth_belt	max_picth_belt	0.000000e+00
max_yaw_belt	max_yaw_belt	0.000000e+00
min_roll_belt	min_roll_belt	0.000000e+00

```
min_pitch_belt                                    min_pitch_belt 0.000000e+00
min_yaw_belt                                        min_yaw_belt 0.000000e+00
amplitude_roll_belt                          amplitude_roll_belt 0.000000e+00
amplitude_pitch_belt                        amplitude_pitch_belt 0.000000e+00
amplitude_yaw_belt                            amplitude_yaw_belt 0.000000e+00
var_total_accel_belt                        var_total_accel_belt 0.000000e+00
avg_roll_belt                                      avg_roll_belt 0.000000e+00
stddev_roll_belt                                stddev_roll_belt 0.000000e+00
var_roll_belt                                      var_roll_belt 0.000000e+00
avg_pitch_belt                                    avg_pitch_belt 0.000000e+00
stddev_pitch_belt                              stddev_pitch_belt 0.000000e+00
var_pitch_belt                                    var_pitch_belt 0.000000e+00
avg_yaw_belt                                        avg_yaw_belt 0.000000e+00
stddev_yaw_belt                                  stddev_yaw_belt 0.000000e+00
var_accel_arm                                      var_accel_arm 0.000000e+00
avg_roll_arm                                        avg_roll_arm 0.000000e+00
stddev_roll_arm                                  stddev_roll_arm 0.000000e+00
var_roll_arm                                        var_roll_arm 0.000000e+00
avg_pitch_arm                                      avg_pitch_arm 0.000000e+00
stddev_pitch_arm                                stddev_pitch_arm 0.000000e+00
var_pitch_arm                                      var_pitch_arm 0.000000e+00
avg_yaw_arm                                          avg_yaw_arm 0.000000e+00
stddev_yaw_arm                                    stddev_yaw_arm 0.000000e+00
var_yaw_arm                                          var_yaw_arm 0.000000e+00
kurtosis_roll_arm                              kurtosis_roll_arm 0.000000e+00
kurtosis_picth_arm                            kurtosis_picth_arm 0.000000e+00
kurtosis_yaw_arm                                kurtosis_yaw_arm 0.000000e+00
skewness_roll_arm                              skewness_roll_arm 0.000000e+00
skewness_pitch_arm                            skewness_pitch_arm 0.000000e+00
skewness_yaw_arm                                skewness_yaw_arm 0.000000e+00
max_roll_arm                                        max_roll_arm 0.000000e+00
max_picth_arm                                      max_picth_arm 0.000000e+00
max_yaw_arm                                          max_yaw_arm 0.000000e+00
min_roll_arm                                        min_roll_arm 0.000000e+00
min_pitch_arm                                      min_pitch_arm 0.000000e+00
min_yaw_arm                                          min_yaw_arm 0.000000e+00
amplitude_roll_arm                            amplitude_roll_arm 0.000000e+00
amplitude_pitch_arm                          amplitude_pitch_arm 0.000000e+00
amplitude_yaw_arm                              amplitude_yaw_arm 0.000000e+00
kurtosis_roll_dumbbell                    kurtosis_roll_dumbbell 0.000000e+00
kurtosis_picth_dumbbell                  kurtosis_picth_dumbbell 0.000000e+00
skewness_roll_dumbbell                    skewness_roll_dumbbell 0.000000e+00
skewness_pitch_dumbbell                  skewness_pitch_dumbbell 0.000000e+00
max_roll_dumbbell                              max_roll_dumbbell 0.000000e+00
max_picth_dumbbell                            max_picth_dumbbell 0.000000e+00
max_yaw_dumbbell                                max_yaw_dumbbell 0.000000e+00
min_roll_dumbbell                              min_roll_dumbbell 0.000000e+00
min_pitch_dumbbell                            min_pitch_dumbbell 0.000000e+00
min_yaw_dumbbell                                min_yaw_dumbbell 0.000000e+00
amplitude_roll_dumbbell                  amplitude_roll_dumbbell 0.000000e+00
amplitude_pitch_dumbbell                amplitude_pitch_dumbbell 0.000000e+00
amplitude_yaw_dumbbell                    amplitude_yaw_dumbbell 0.000000e+00
var_accel_dumbbell                            var_accel_dumbbell 0.000000e+00
avg_roll_dumbbell                              avg_roll_dumbbell 0.000000e+00
stddev_roll_dumbbell                        stddev_roll_dumbbell 0.000000e+00
var_roll_dumbbell                              var_roll_dumbbell 0.000000e+00
avg_pitch_dumbbell                            avg_pitch_dumbbell 0.000000e+00
```

```
stddev_pitch_dumbbell                    stddev_pitch_dumbbell 0.000000e+00
var_pitch_dumbbell                          var_pitch_dumbbell 0.000000e+00
avg_yaw_dumbbell                               avg_yaw_dumbbell 0.000000e+00
stddev_yaw_dumbbell                        stddev_yaw_dumbbell 0.000000e+00
var_yaw_dumbbell                               var_yaw_dumbbell 0.000000e+00
kurtosis_roll_forearm                    kurtosis_roll_forearm 0.000000e+00
kurtosis_picth_forearm                  kurtosis_picth_forearm 0.000000e+00
skewness_roll_forearm                    skewness_roll_forearm 0.000000e+00
skewness_pitch_forearm                  skewness_pitch_forearm 0.000000e+00
max_roll_forearm                               max_roll_forearm 0.000000e+00
max_picth_forearm                             max_picth_forearm 0.000000e+00
max_yaw_forearm                                 max_yaw_forearm 0.000000e+00
min_roll_forearm                               min_roll_forearm 0.000000e+00
min_yaw_forearm                                 min_yaw_forearm 0.000000e+00
amplitude_roll_forearm                  amplitude_roll_forearm 0.000000e+00
amplitude_pitch_forearm                amplitude_pitch_forearm 0.000000e+00
amplitude_yaw_forearm                    amplitude_yaw_forearm 0.000000e+00
var_accel_forearm                             var_accel_forearm 0.000000e+00
avg_roll_forearm                               avg_roll_forearm 0.000000e+00
stddev_roll_forearm                        stddev_roll_forearm 0.000000e+00
var_roll_forearm                               var_roll_forearm 0.000000e+00
avg_pitch_forearm                             avg_pitch_forearm 0.000000e+00
stddev_pitch_forearm                      stddev_pitch_forearm 0.000000e+00
var_pitch_forearm                             var_pitch_forearm 0.000000e+00
avg_yaw_forearm                                 avg_yaw_forearm 0.000000e+00
stddev_yaw_forearm                          stddev_yaw_forearm 0.000000e+00
var_yaw_forearm                                 var_yaw_forearm 0.000000e+00
accel_forearm_y.1                             accel_forearm_y.1 0.000000e+00
accel_forearm_z.1                             accel_forearm_z.1 0.000000e+00
magnet_forearm_x.1                           magnet_forearm_x.1 0.000000e+00
magnet_forearm_y.1                           magnet_forearm_y.1 0.000000e+00
magnet_forearm_z.1                           magnet_forearm_z.1 0.000000e+00
classeB                                                 classeB 0.000000e+00
classeC                                                 classeC 0.000000e+00
classeD                                                 classeD 0.000000e+00
> # make predictions
> predictions<- predict(gbm_mod,dataTest)
>
> # append predictions
> pred<- cbind(dataTest,predictions)
>
> # summarize results
> confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)
Error: `data` and `reference` should be factors with the same levels.
> confusionMatrix
Confusion Matrix and Statistics

          Reference
Prediction    A    B    C    D    E
         A 1365    0    0    0    0
         B    0  901    0    0    0
         C    0    0   92    0    0
         D    0    0    0  276    0
         E    0    0    0    0 1370

Overall Statistics
```

```
                   Accuracy : 1
                     95% CI : (0.9991, 1)
        No Information Rate : 0.3422
        P-Value [Acc > NIR] : < 2.2e-16

                      Kappa : 1
     Mcnemar's Test P-Value : NA

Statistics by Class:

                     Class: A Class: B Class: C Class: D Class: E
Sensitivity            1.0000    1.000  1.00000  1.00000    1.0000
Specificity            1.0000    1.000  1.00000  1.00000    1.0000
Pos Pred Value         1.0000    1.000  1.00000  1.00000    1.0000
Neg Pred Value         1.0000    1.000  1.00000  1.00000    1.0000
Prevalence             0.3409    0.225  0.02298  0.06893    0.3422
Detection Rate         0.3409    0.225  0.02298  0.06893    0.3422
Detection Prevalence   0.3409    0.225  0.02298  0.06893    0.3422
Balanced Accuracy      1.0000    1.000  1.00000  1.00000    1.0000
```