Session 18 Assignment

5. Problem Statement

1. Use the below given data set

DataSet

- 2. Perform the below given activities:
- a. Create classification model using different decision trees.
- b. Verify model goodness of fit.
- c. Apply all the model validation techniques.
- d. Make conclusions

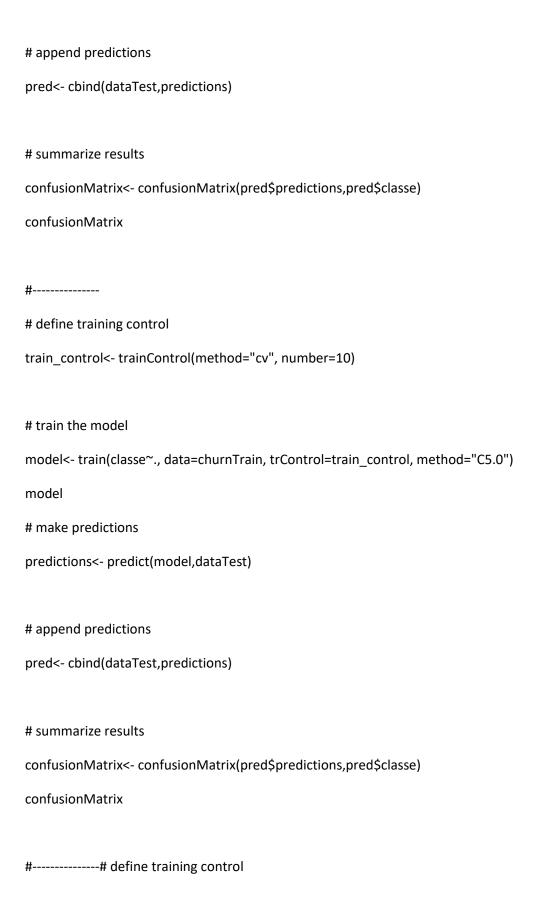
setwd("C:/Users/Seshan/Desktop/sv R related/acadgild/assignments/session 18 Assign/session18")
library(readr)
Weight_lift <- read.csv("Weight lift.csv")
View(Weight_lift)
data1<-Weight_lift
Weight_lift
load libraries
library(caret)
library(randomForest)
library(rpart)
library(rpart.plot)
library(ggplot2)
library(lattice)
library(rattle)
summary(data1)
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)
library(caret)
library(zoo)
library(plyr)
data<-na.exclude(data1)
is.na(data)
which(is.na(data))
sum(is.na(data))
colSums(is.na(data))
#data[is.na(data)] <- mean(data, na.rm = TRUE)</pre>
str(data)
summary(data)
pairs(data[8:15])
# enable multi-core processing
library(doParallel)
#cl <- makeCluster(detectCores())
registerDoParallel()
set.seed(12345)
dataTrain<-data[1:800,]
```

```
dataTest<-data[805:4024,]
head(dataTrain)
head(dataTest)
indexNA <- as.vector(sapply(dataTrain[,1:152],function(x) \{length(which(is.na(x)))!=0\}))\\
dataTrain <- dataTrain[,!indexNA]</pre>
dataTrain<-na.exclude(dataTrain)
library(C50)
head(dataTrain)
head(dataTest)
#-----
library(tree)
fit <-tree(classe~.,data=dataTrain[,-1])</pre>
summary(fit)
#fit
plot(fit)
text(fit)
pred <-predict(fit,dataTest[,-1],type='class')</pre>
```

confusionMatrix(pred,dataTest\$classe)

```
#----
library(rpart)
library(rpart.plot)
fit1 <- rpart(classe~.,data=dataTrain[,-1])</pre>
fit1
summary(fit1)
# make predictions
pred <- predict(fit1,dataTest[,-1],type='class')</pre>
confusionMatrix(pred,dataTest$classe)
rpart.plot::rpart.plot(fit1)
#-----
# load libraries
library(caret)
library(rpart)
# define training control
train_control<- trainControl(method="cv", number=10)</pre>
# train the model
model<- train(classe~., data=dataTrain, trControl=train_control, method="rpart")
model
# make predictions
predictions<- predict(model,dataTest)</pre>
```



```
train_control<- trainControl(method="cv", number=10)</pre>
# train the model
model<- train(classe~., data=churnTrain, trControl=train_control, method="bstTree")
model
# make predictions
predictions<- predict(model,dataTest)</pre>
# append predictions
pred<- cbind(dataTest,predictions)</pre>
# summarize results
confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)
confusionMatrix
#-----
# define training control
train_control<- trainControl(method="cv", number=10)</pre>
# train the model
model<- train(classe~., data=dataTrain, trControl=train_control, method="C5.0Cost")
model
# make predictions
predictions<- predict(model,dataTest)</pre>
```

```
# append predictions
pred<- cbind(dataTest,predictions)</pre>
# summarize results
confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)
confusionMatrix
#-----
# define training control
train_control<- trainControl(method="cv", number=10)</pre>
# train the model
model<- train(classe~., data=dataTrain, trControl=train_control, method="C5.0Rules")
model
# make predictions
predictions<- predict(model,dataTest)</pre>
# append predictions
pred<- cbind(dataTest,predictions)</pre>
# summarize results
confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)
confusion \\ Matrix
```

```
#-----
# define training control
train_control<- trainControl(method="cv", number=10)</pre>
# train the model
model<- train(classe~., data=dataTrain, trControl=train_control, method="C5.0Tree")
model
# make predictions
predictions<- predict(model,dataTest)</pre>
# append predictions
pred<- cbind(dataTest,predictions)</pre>
# summarize results
confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)
confusionMatrix
#-----
# define training control
train_control<- trainControl(method="cv", number=10)</pre>
# train the model
model<- train(classe~., data=dataTrain, trControl=train_control, method="ctree")
model
```

```
# make predictions
predictions<- predict(model,dataTest)</pre>
# append predictions
pred<- cbind(dataTest,predictions)</pre>
# summarize results
confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)
confusionMatrix
#-----
# define training control
train_control<- trainControl(method="cv", number=10)</pre>
# train the model
model<- train(classe~., data=dataTrain, trControl=train_control, method="ctree2")
model
# make predictions
predictions<- predict(model,dataTest)</pre>
# append predictions
pred<- cbind(dataTest,predictions)</pre>
# summarize results
confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)
confusionMatrix
```

```
> setwd("C:/Users/Seshan/Desktop/sv R related/acadgild/assignments/session 18
Assign/session18")
> library(readr)
> Weight_lift <- read.csv("Weight lift.csv")</pre>
> View(Weight_lift)
> data1<-Weight_lift</pre>
> Weight_lift
     accel_forearm_z magnet_forearm_x magnet_forearm_y magnet_forearm_z
1
                  184
                                  -1160
                                                    1400
                                                                       -876
2
                  182
                                  -1150
                                                    1410
                                                                       -871
3
                  185
                                  -1130
                                                                       -863
                                                     1400
4
                  188
                                  -1120
                                                     1400
                                                                       -855
5
                  188
                                  -1100
                                                     1400
                                                                       -843
6
                  190
                                  -1090
                                                    1400
                                                                       -838
     accel_forearm_y.1 accel_forearm_z.1 magnet_forearm_x.1 magnet_forearm_y.
1
                    155
                                       184
                                                         -1160
                                                                              140
1
0
2
                    164
                                       182
                                                                              141
                                                         -1150
0
3
                    172
                                       185
                                                         -1130
                                                                              140
0
4
                    182
                                       188
                                                         -1120
                                                                              140
0
5
                    195
                                       188
                                                         -1100
                                                                              140
0
                    207
                                       190
6
                                                         -1090
                                                                              140
0
     magnet_forearm_z.1 classe
1
                    -876
                              Ε
2
                    -871
                              Ε
3
                    -863
                              Ε
4
                    -855
                              Ε
5
                    -843
                              Ε
6
                    -838
                              Ε
 [ reached getOption("max.print") -- omitted 4018 rows ]
> # load libraries
> library(caret)
> library(randomForest)
> library(rpart)
> library(rpart.plot)
> library(ggplot2)
> library(lattice)
> library(rattle)
Error in library(rattle) : there is no package called 'rattle'
> summary(data1)
    user_name
                 raw_timestamp_part_1 raw_timestamp_part_2
                                                                       cvtd_time
stamp
 adelmo : 311
                  Min.
                         :1.322e+09
                                                   297
                                                              2/12/2011 13:35 :
                                        Min.
311
 carlitos:1580
                 1st Qu.:1.323e+09
                                        1st Qu.:244321
                                                              28/11/2011 14:15:
                                        Median :492342
                 Median :1.323e+09
                                                              30/11/2011 17:12:
 eurico : 88
```

```
5/12/2011 11:23 :
 jeremy
                 Mean
                        :1.323e+09
                                      Mean
                                             :490377
337
         :2041
                 3rd Qu.:1.323e+09
                                      3rd Qu.:736278
                                                           5/12/2011 11:25 :1
 pedro
243
                        :1.323e+09
                                             :996453
                                                           5/12/2011 14:22 :
                 Max.
                                      Max.
456
                                                                 yaw_belt
 new window
              num window
                              roll belt
                                               pitch belt
                                   :-28.90
                                                              Min.
 no:3936
                                                    :-56.20
                                                                     :-179.00
            Min. : 1.00
                            Min.
                                             Min.
0
yes: 88
                                             1st Qu.: 6.22
            1st Ou.:24.00
                            1st Qu.: 1.38
                                                              1st Qu.: -93.10
            Median :46.00
                            Median :122.00
                                             Median : 25.50
                                                              Median : -4.94
0
            Mean
                   :46.33
                            Mean
                                   : 73.31
                                             Mean
                                                    : 14.16
                                                              Mean
                                                                     : -30.97
5
                                             3rd Qu.: 26.40
            3rd Qu.:69.00
                            3rd Qu.:124.00
                                                              3rd Qu.: -2.69
5
                                   :159.00
                                                    : 60.30
            Max.
                   :91.00
                            Max.
                                             Max.
                                                              Max.
                                                                      : 179.00
0
 total_accel_belt kurtosis_roll_belt kurtosis_picth_belt skewness_roll_belt
       : 0.00
                  Min. :-3.333
                                     Min. :-2.1212
                                                         Min. :-3.031527
                  1st Qu.:-1.036
                                     1st Qu.:-0.3913
 1st Qu.: 3.00
                                                         1st Qu.: 0.005406
 Median :19.00
                  Median :-1.036
                                     Median :-0.3913
                                                         Median: 0.005406
       :12.77
                       :-1.027
                                            :-0.3496
                                                         Mean : 0.003858
 Mean
                  Mean
                                     Mean
                                     3rd Qu.:-0.3913
                  3rd Qu.:-1.036
                                                         3rd Qu.: 0.005406
 3rd Qu.:20.00
                                                               : 2.713152
                        : 7.515
        :26.00
                  Max.
                                     Max.
                                            :54.0000
                                                         Max.
                                                         max_yaw_belt
 skewness roll belt.1 max roll belt
                                        max picth belt
       :-6.63325
                      Min.
                            :-94.400
                                               : 3.00
                                                        Min.
                                                               :-3.3000
 Min.
                                        Min.
 1st Ou.: 0.04512
                      1st Qu.: -4.100
                                        1st Qu.:20.00
                                                        1st Ou.:-1.0000
 Median : 0.04512
                      Median : -4.100
                                        Median :20.00
                                                        Median :-1.0000
                                                               :-0.9917
 Mean
        : 0.04011
                      Mean
                             : -4.626
                                        Mean
                                               :19.87
                                                        Mean
 3rd Qu.: 0.04512
                      3rd Qu.: -4.100
                                        3rd Qu.:20.00
                                                        3rd Qu.:-1.0000
                                                               : 7.5000
       : 7.34847
                             :179.000
 Max.
                      Max.
                                        Max.
                                               :26.00
                                                        Max.
 min_roll_belt
                    min_pitch_belt
                                     min_yaw_belt
                                                      amplitude roll belt
 Min.
       :-179.000
                    Min.
                          : 0.00
                                    Min.
                                           :-3.3000
                                                      Min.
                                                             : 0.000
                                                                1.345
 1st Qu.:
          -7.250
                    1st Qu.:18.00
                                    1st Qu.:-1.0000
                                                      1st Qu.:
          -7.250
 Median:
                    Median :18.00
                                    Median :-1.0000
                                                      Median :
                                                                1.345
          -7.838
                           :17.86
                                    Mean
                                          :-0.9917
                                                      Mean
                                                                1.446
 Mean
                    Mean
 3rd Qu.:
         -7.250
                    3rd Qu.:18.00
                                    3rd Qu.:-1.0000
                                                      3rd Qu.: 1.345
       : 157.000
                    Max. :20.00
                                    Max. : 7.5000
                                                            :358.000
                                                      Max.
 amplitude_pitch_belt amplitude_yaw_belt var_total_accel_belt avg_roll_belt
       : 0.000
                      Min.
                             :0
                                         Min.
                                                : 0.0000
                                                              Min.
 Min.
                                                                     :-27.4
 1st Qu.: 2.000
                      1st Qu.:0
                                         1st Qu.: 0.3000
                                                              1st Qu.:121.9
 Median : 2.000
                      Median:0
                                         Median : 0.3000
                                                              Median :121.9
        : 2.014
 Mean
                      Mean
                             :0
                                         Mean
                                                : 0.3148
                                                              Mean
                                                                     :120.8
 3rd Qu.: 2.000
                      3rd Qu.:0
                                         3rd Qu.: 0.3000
                                                              3rd Qu.:121.9
        :21.000
                             :0
                                                :18.2000
                                                                      :154.5
 Max.
                      Max.
                                         Max.
                                                              Max.
 avg_yaw_forearm
                   stddev_yaw_forearm var_yaw_forearm gyros_forearm_x
       :-152.33
                                                 0
 Min.
                   Min. : 0.00
                                      Min. :
                                                      Min.
                                                             :-1.8800
                                                      1st Qu.:-0.1400
 1st Qu.: 17.10
                   1st Qu.: 74.28
                                      1st Qu.: 5542
                   Median : 74.28
                                      Median: 5542
 Median :
          17.10
                                                      Median : 0.0600
 Mean
       : 17.13
                   Mean : 74.01
                                      Mean : 5578
                                                      Mean
                                                            : 0.1076
                                      3rd Qu.: 5542
 3rd Qu.: 17.10
                   3rd Qu.: 74.28
                                                      3rd Qu.: 0.4200
                                      Max. :39009
                                                            : 1.8100
 Max. : 132.59
                   Max. :197.51
                                                      Max.
 gyros_forearm_y
                     gyros_forearm_z
                                        accel_forearm_x
                                                           accel_forearm_y
       :-5.730000
                     Min. :-2.58000
                                        Min. :-328.000
                                                           Min.
                                                                  :-467.00
```

```
1st Qu.:-1.780000
                     1st Qu.:-0.31000
                                         1st Qu.:-117.000
                                                            1st Qu.: 75.75
                                                            Median : 229.50
                     Median :-0.02000
                                         Median : -6.000
 Median :-0.020000
                     Mean : 0.09302
        :-0.004108
                                         Mean : -6.445
                                                            Mean
                                                                   : 171.47
 3rd Qu.: 1.830000
                     3rd Qu.: 0.48000
                                         3rd Qu.: 113.000
                                                            3rd Qu.: 297.00
 Max. : 5.170000
                     Max.
                          : 3.35000
                                         Max.
                                              : 279.000
                                                            Max. : 575.00
 accel_forearm_z magnet_forearm_x magnet_forearm_y magnet_forearm_z
                                                            :-876.0
 Min. :-366
                 Min.
                        :-1160.0
                                   Min.
                                           :-725.0
                                                     Min.
                                    1st Qu.: -76.0
                                                     1st Qu.: 370.8
 1st Qu.:-210
                 1st Qu.: -589.0
                 Median : -330.5
                                    Median : 653.0
                                                     Median: 560.0
 Median :-181
                 Mean : -348.7
                                           : 358.6
                                                          : 475.2
       :-163
                                    Mean
                                                     Mean
 3rd Qu.:-150
                 3rd Qu.: -152.0
                                    3rd Qu.: 747.0
                                                     3rd Qu.: 670.0
       : 239
                                                            :1040.0
                 Max.
                       : 413.0
                                   Max.
                                          :1440.0
                                                     Max.
 accel_forearm_y.1 accel_forearm_z.1 magnet_forearm_x.1 magnet_forearm_y.1
                                                                 :-725.0
        :-467.00
                          :-366
                                             :-1160.0
                                                         Min.
 1st Qu.: 75.75
                                                         1st Qu.: -76.0
                   1st Qu.:-210
                                      1st Qu.: -589.0
 Median : 229.50
                                      Median: -330.5
                   Median :-181
                                                         Median: 653.0
       : 171.47
                   Mean :-163
                                      Mean : -348.7
                                                         Mean : 358.6
 Mean
 3rd Qu.: 297.00
                   3rd Qu.:-150
                                      3rd Qu.: -152.0
                                                         3rd Qu.: 747.0
      : 575.00
                         : 239
                   Max.
                                           : 413.0
                                                                 :1440.0
 magnet_forearm_z.1 classe
                    A:1365
      :-876.0
                    B: 901
 1st Qu.: 370.8
 Median : 560.0
                    c: 112
        : 475.2
                    D: 276
 3rd Qu.: 670.0
                    E:1370
        :1040.0
 [ reached getOption("max.print") -- omitted 1 row ]
> library(C50)
> library(helpRFunctions)
> names(data)
  [1] "user_name"
                                  "raw_timestamp_part_1"
                                                              "raw_timestamp_pa
rt_2"
                                  "new_window"
  [4] "cvtd_timestamp"
                                                              "num_window"
  [7] "roll_belt"
                                  "pitch_belt"
                                                              "yaw_belt"
                                                              "kurtosis_picth_b
 [10]
     "total_accel_belt"
                                  "kurtosis_roll_belt"
elt"
                                  "skewness_roll_belt.1"
                                                             "max_roll_belt"
 [13] "skewness_roll_belt"
 [16] "max_picth_belt"
                                  "max_yaw_belt"
                                                             "min_roll_belt"
 [19] "min_pitch_belt"
                                  "min_yaw_belt"
                                                              "amplitude_roll_b
elt"
                                                             "var_total_accel_
 [22] "amplitude_pitch_belt"
                                  "amplitude_yaw_belt"
belt"
                                  "stddev_roll_belt"
 [25] "avg_roll_belt"
                                                              "var_roll_belt"
                                  "stddev_pitch_belt"
 [28] "avg_pitch_belt"
                                                             "var_pitch_belt"
                                  "stddev_yaw_belt"
 [31] "avg_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"
                                  "classe"
[157] "magnet_forearm_z.1"
> dim(data)
[1] 4024 158
> library(caret)
> library(zoo)
> library(plyr)
> data<-na.exclude(data1)</pre>
> is.na(data)
```

indow	er_name raw	_timesta	mp_part_1	raw_timest	amp_part_2 o	cvtd_timestamp	new_v
111dow 1	FALSE		FALSE		FALSE	FALSE	
FALSE 2	FALSE		FALSE		FALSE	FALSE	
ALSE							
} FALSE	FALSE		FALSE		FALSE	FALSE	
I FALSE	FALSE		FALSE		FALSE	FALSE	
;	FALSE		FALSE		FALSE	FALSE	
ALSE	FALSE		FALSE		FALSE	FALSE	
ALSE	m window ro]] he]+	nitch helt	vaw holt	total accel	_belt kurtosis_	roll
elt	III_WIIIGOW IO	TI_beic	priccii_berc	yaw_berc	total_accel_	_Deit Kuitosis_	_1011_
LSE	FALSE	FALSE	FALSE	FALSE	F	FALSE	F
	FALSE	FALSE	FALSE	FALSE	F	FALSE	F
LSE	FALSE	FALSE	FALSE	FALSE	F	FALSE	F
LSE							F
LSE	FALSE	FALSE	FALSE	FALSE	Г	FALSE	Г
LSE	FALSE	FALSE	FALSE	FALSE	F	FALSE	F
	FALSE	FALSE	FALSE	FALSE	F	FALSE	F
LSE							
LSE ma _arm	x_roll_arm	max_pict	h_arm max_ _Y	yaw_arm mi	n_roll_arm n	nin_pitch_arm ı	
LSE ma _arm ALSE	x_roll_arm FALSE	max_pict	h_arm max_: FALSE	yaw_arm mi FALSE	n_roll_arm n FALSE	nin_pitch_arm ı FALSE	
Ma Marm Mars	x_roll_arm FALSE FALSE	max_pict	h_arm max_ <u>'</u> FALSE FALSE	yaw_arm mi FALSE FALSE	n_roll_arm n FALSE FALSE	nin_pitch_arm n FALSE FALSE	
MLSE ma /_arm - FALSE FALSE	x_roll_arm FALSE	max_pict	h_arm max_: FALSE	yaw_arm mi FALSE	n_roll_arm n FALSE	nin_pitch_arm ı FALSE	
ma /_arm - FALSE - FALSE - FALSE	x_roll_arm FALSE FALSE	max_pict	h_arm max_ <u>'</u> FALSE FALSE	yaw_arm mi FALSE FALSE	n_roll_arm n FALSE FALSE	nin_pitch_arm n FALSE FALSE	
ma v_arm l FALSE 2 FALSE 3 FALSE 4 FALSE 5	x_roll_arm FALSE FALSE FALSE	max_pict	h_arm max_ FALSE FALSE FALSE	yaw_arm mi FALSE FALSE FALSE	n_roll_arm n FALSE FALSE FALSE	nin_pitch_arm n FALSE FALSE FALSE	
ALSE	x_roll_arm FALSE FALSE FALSE FALSE FALSE	max_pict	h_arm max_; FALSE FALSE FALSE FALSE	yaw_arm mi FALSE FALSE FALSE FALSE	n_roll_arm n FALSE FALSE FALSE FALSE	nin_pitch_arm i FALSE FALSE FALSE FALSE FALSE	
MLSE ma w_arm false false false false false false false false false	x_roll_arm FALSE FALSE FALSE FALSE FALSE FALSE FALSE	max_pict	h_arm max_ FALSE FALSE FALSE FALSE FALSE	yaw_arm mi FALSE FALSE FALSE FALSE FALSE FALSE	n_roll_arm n FALSE FALSE FALSE FALSE FALSE FALSE FALSE	nin_pitch_arm i FALSE FALSE FALSE FALSE FALSE FALSE	min_ya
MLSE mav_arm L FALSE 3 FALSE 4 FALSE 5 FALSE 6 FALSE 6 FALSE am	x_roll_arm FALSE FALSE FALSE FALSE FALSE FALSE FALSE plitude_rol	max_pict l_arm am	h_arm max_ FALSE FALSE FALSE FALSE FALSE	yaw_arm mi FALSE FALSE FALSE FALSE FALSE FALSE tch_arm am	n_roll_arm n FALSE FALSE FALSE FALSE FALSE FALSE	nin_pitch_arm n FALSE FALSE FALSE FALSE FALSE FALSE	min_ya
MLSE mav_arm L FALSE 3 FALSE 4 FALSE 5 FALSE 6 FALSE 6 FALSE am	x_roll_arm FALSE FALSE FALSE FALSE FALSE FALSE plitude_rol	max_pict	h_arm max_ FALSE FALSE FALSE FALSE FALSE	yaw_arm mi FALSE FALSE FALSE FALSE FALSE FALSE	n_roll_arm n FALSE FALSE FALSE FALSE FALSE FALSE FALSE	nin_pitch_arm n FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE	min_ya
MLSE mav_arm L FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE am	x_roll_arm FALSE FALSE FALSE FALSE FALSE FALSE plitude_rol	max_pict l_arm am FALSE FALSE FALSE	h_arm max_ FALSE FALSE FALSE FALSE FALSE	yaw_arm mi FALSE FALSE FALSE FALSE FALSE tch_arm am FALSE FALSE FALSE FALSE	n_roll_arm n FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE	nin_pitch_arm n FALSE	min_ya bell ALSE ALSE ALSE
MLSE mav_arm L FALSE 3 FALSE 4 FALSE 5 FALSE 6 FALSE 6 FALSE am	x_roll_arm FALSE FALSE FALSE FALSE FALSE FALSE plitude_rol	max_pict l_arm am FALSE FALSE FALSE FALSE	h_arm max_ FALSE FALSE FALSE FALSE FALSE	yaw_arm mi FALSE FALSE FALSE FALSE FALSE tch_arm am FALSE FALSE FALSE FALSE FALSE FALSE FALSE	n_roll_arm n FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE	nin_pitch_arm in FALSE	min_ya bell ALSE ALSE ALSE ALSE
MLSE mav_arm L FALSE 3 FALSE 4 FALSE 5 FALSE 6 FALSE 6 FALSE am	x_roll_arm FALSE FALSE FALSE FALSE FALSE plitude_rol	nax_pict l_arm am FALSE FALSE FALSE FALSE FALSE FALSE	h_arm max_ FALSE FALSE FALSE FALSE FALSE	yaw_arm mi FALSE FALSE FALSE FALSE FALSE tch_arm am FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE	n_roll_arm n FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE	nin_pitch_arm in FALSE	min_ya bell ALSE ALSE ALSE ALSE ALSE
MLSE mav_arm L FALSE 2 FALSE 4 FALSE 5 FALSE 6 FALSE 6 FALSE 2 3 4 5 6	x_roll_arm FALSE FALSE FALSE FALSE FALSE plitude_rol	nax_pict l_arm am FALSE FALSE FALSE FALSE FALSE FALSE FALSE	h_arm max_y FALSE FALSE FALSE FALSE FALSE plitude_pi	yaw_arm mi FALSE FALSE FALSE FALSE FALSE TALSE FALSE	n_roll_arm n FALSE	nin_pitch_arm in FALSE	min_ya bell ALSE ALSE ALSE ALSE ALSE
MLSE ma v_arm 1 FALSE 2 FALSE 4 FALSE 5 FALSE 6 FALSE 2 3 4 5 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	x_roll_arm FALSE FALSE FALSE FALSE FALSE plitude_rol	nax_pict l_arm am FALSE FALSE FALSE FALSE FALSE FALSE FALSE	h_arm max_y FALSE FALSE FALSE FALSE FALSE plitude_pi	yaw_arm mi FALSE FALSE FALSE FALSE FALSE TALSE FALSE	n_roll_arm n FALSE	nin_pitch_arm in FALSE	min_ya bell ALSE ALSE ALSE ALSE ALSE
MALSE ma w_arm false False False False False am 1 2 3 4 5 6 pi 11	x_roll_arm FALSE FALSE FALSE FALSE FALSE plitude_rol	nax_pict l_arm am FALSE FALSE FALSE FALSE FALSE FALSE I yaw_du	h_arm max_y FALSE FALSE FALSE FALSE FALSE plitude_pi	yaw_arm mi FALSE FALSE FALSE FALSE FALSE TALSE FALSE	n_roll_arm n FALSE	nin_pitch_arm in FALSE	min_ya bell ALSE ALSE ALSE ALSE dumbbe
MALSE ma w_arm FALSE FALSE FALSE FALSE FALSE TALSE FALSE FALSE pi	x_roll_arm FALSE FALSE FALSE FALSE FALSE plitude_rol	nax_pict l_arm am FALSE FALSE FALSE FALSE FALSE FALSE I yaw_du	h_arm max_y FALSE FALSE FALSE FALSE plitude_pi	yaw_arm mi FALSE FALSE FALSE FALSE FALSE TALSE FALSE	n_roll_arm n FALSE FALSE FALSE FALSE FALSE FALSE ALSE FALSE FALSE FALSE ALSE ALSE ALSE ALSE ALSE ALSE ALSE	nin_pitch_arm in FALSE	min_ya bell ALSE ALSE ALSE ALSE ALSE

3	FALSE	FALSE		FALSE		FAL
SE 4	FALSE	FALSE		FALSE		FAL
SE 5	FALSE	FALSE		FALSE		FAL
SE 6 SE	FALSE	FALSE		FALSE		FAL
	skewness_roll_dum		ss_pitch_			
1 2		FALSE FALSE		FALSE FALSE	FALSE FALSE	
3		FALSE		FALSE	FALSE	
4 5		FALSE FALSE		FALSE FALSE	FALSE FALSE	
6		FALSE		FALSE	FALSE	
_	max_picth_dumbbel					
1 2	FALS FALS		FALSE FALSE	FAL FAL		FALSE FALSE
3	FALS		FALSE	FAL		FALSE
4 5	FALS		FALSE	FAL	SE	FALSE
5 6	FALS FALS		FALSE FALSE	FAL		FALSE
O	min_yaw_dumbbell			FAL 11 amplitude		FALSE
1	FALSE		FAL	SE	FALSE	-
2	FALSE		FAL		FALSE	
3 4	FALSE FALSE		FAL: FAL:		FALSE FALSE	
5	FALSE		FAL		FALSE	
6	FALSE		FAL		FALSE	
dumb	amplitude_yaw_dum	ibbell total_a	accel_dum	bbell var_acc	el_dumbbell av	g_roll_
1	Jeii	FALSE		FALSE	FALSE	
FALS	Ē					
2 FALS	=	FALSE		FALSE	FALSE	
3	_	FALSE		FALSE	FALSE	
FALS	Ē					
4 FALS	=	FALSE		FALSE	FALSE	
5		FALSE		FALSE	FALSE	
FALS	<u> </u>	FALSE		FALSE	FALSE	
FALS	≣ stddev_roll_dumbb	mell var roll	dumbbe11	avo nitch du	mhhell stddev	nitch d
umbb		7611 Var_1011	_ddillbbc i i	avg_preen_aa	mbberr seacev_	prccii_u
1		LSE	FALSE		FALSE	
FALS 2		LSE	FALSE		FALSE	
FALS			TALSE		TALSE	
3 FALS		ALSE	FALSE		FALSE	
4	FA	ALSE	FALSE		FALSE	
FALS 5	FA	ALSE	FALSE		FALSE	
FALS		LSE	FALSE		FALSE	
FALS		_J_	IALJE		ALJE	

```
var_pitch_dumbbell avg_yaw_dumbbell stddev_yaw_dumbbell var_yaw_dumbbell
1
                   FALSE
                                     FALSE
                                                           FALSE
                                                                              FALSE
2
                   FALSE
                                     FALSE
                                                           FALSE
                                                                              FALSE
3
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                                     FALSE
                                                           FALSE
                                                                              FALSE
4
                   FALSE
                                     FALSE
                                                           FALSE
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5
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                                     FALSE
                                                           FALSE
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6
                   FALSE
                                     FALSE
                                                           FALSE
     gyros_dumbbell_x gyros_dumbbell_y gyros_dumbbell_z accel_dumbbell_x
1
                 FALSE
                                   FALSE
                                                      FALSE
                                                                        FALSE
2
                 FALSE
                                   FALSE
                                                      FALSE
                                                                        FALSE
3
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4
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5
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                                                                        FALSE
6
                 FALSE
                                   FALSE
                                                      FALSE
                                                                        FALSE
     accel_dumbbell_y accel_dumbbell_z magnet_dumbbell_x magnet_dumbbell_y
1
                 FALSE
                                   FALSE
                                                       FALSE
                                                                          FALSE
2
                 FALSE
                                   FALSE
                                                       FALSE
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3
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4
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5
                 FALSE
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                                                                          FALSE
6
                 FALSE
                                   FALSE
                                                       FALSE
                                                                          FALSE
     magnet_dumbbell_z roll_forearm pitch_forearm yaw_forearm kurtosis_roll_f
                  FALSE
                                FALSE
                                               FALSE
                                                            FALSE
FALSE
                  FALSE
                                FALSE
                                               FALSE
                                                            FALSE
FALSE
                                FALSE
                                               FALSE
3
                  FALSE
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4
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5
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6
                  FALSE
                                FALSE
                                               FALSE
                                                            FALSE
FALSE
     kurtosis_picth_forearm skewness_roll_forearm skewness_pitch_forearm
1
                       FALSE
                                               FALSE
                                                                        FALSE
2
                       FALSE
                                               FALSE
                                                                        FALSE
3
                       FALSE
                                               FALSE
                                                                        FALSE
4
                       FALSE
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                                                                        FALSE
5
                       FALSE
                                               FALSE
                                                                        FALSE
6
                       FALSE
                                               FALSE
                                                                        FALSE
     max_roll_forearm max_picth_forearm max_yaw_forearm min_roll_forearm
1
                 FALSE
                                    FALSE
                                                      FALSE
                                                                        FALSE
2
                 FALSE
                                    FALSE
                                                      FALSE
                                                                        FALSE
3
                 FALSE
                                    FALSE
                                                      FALSE
                                                                        FALSE
4
                 FALSE
                                    FALSE
                                                      FALSE
                                                                        FALSE
5
                 FALSE
                                    FALSE
                                                      FALSE
                                                                        FALSE
6
                 FALSE
                                    FALSE
                                                      FALSE
                                                                        FALSE
     magnet_forearm_z.1 classe
1
                   FALSE FALSE
2
                   FALSE FALSE
3
                   FALSE FALSE
4
                   FALSE FALSE
5
                   FALSE
                          FALSE
6
                   FALSE FALSE
 [ reached getOption("max.print") -- omitted 4018 rows ]
```

```
> which(is.na(data))
integer(0)
> sum(is.na(data))
[1] 0
> colSums(is.na(data))
                              raw_timestamp_part_1
                                                        raw_timestamp_part_2
               user_name
          cvtd timestamp
                                        new window
                                                                   num_window
               roll_belt
                                        pitch_belt
                                                                     yaw_belt
        total_accel_belt
                                kurtosis_roll_belt
                                                         kurtosis_picth_belt
      skewness_roll_belt
                              skewness_roll_belt.1
                                                               max_roll_belt
          max_picth_belt
                                      max_yaw_belt
                                                               min_roll_belt
                                      min_yaw_belt
          min_pitch_belt
                                                         amplitude_roll_belt
    amplitude_pitch_belt
                                amplitude_yaw_belt
                                                        var_total_accel_belt
                                  stddev_roll_belt
           avg_roll_belt
                                                               var_roll_belt
          avg_pitch_belt
                                 stddev_pitch_belt
                                                              var_pitch_belt
                                   stddev_yaw_belt
            avg_yaw_belt
                                                                var_yaw_belt
            gyros_belt_x
                                      gyros_belt_y
                                                                 gyros_belt_z
            accel belt x
                                      accel_belt_y
                                                                accel belt z
           magnet_belt_x
                                     magnet_belt_y
                                                               magnet_belt_z
                roll arm
                                         pitch_arm
                                                                      yaw_arm
         total_accel_arm
                                     var_accel_arm
                                                                avg_roll_arm
         stddev_roll_arm
                                      var_roll_arm
                                                                avg_pitch_arm
        stddev_pitch_arm
                                     var_pitch_arm
                                                                  avg_yaw_arm
          stddev_yaw_arm
                                       var_yaw_arm
                                                                  gyros_arm_x
             gyros_arm_y
                                       gyros_arm_z
                                                                  accel_arm_x
                                       accel_arm_z
             accel_arm_y
                                                                magnet_arm_x
                                                           kurtosis_roll_arm
            magnet_arm_y
                                      magnet_arm_z
      kurtosis_picth_arm
                                  kurtosis_yaw_arm
                                                           skewness_roll_arm
      skewness_pitch_arm
                                                                max_roll_arm
                                  skewness_yaw_arm
           max_picth_arm
                                                                min_roll_arm
                                       max_yaw_arm
           min_pitch_arm
                                                          amplitude_roll_arm
                                       min_yaw_arm
```

amplitude_pitch_arm	amplitude_yaw_arm	roll_dumbbell
pitch_dumbbell	yaw_dumbbell	kurtosis_roll_dumbbell
kurtosis_picth_dumbbell	skewness_roll_dumbbell	skewness_pitch_dumbbell
0 max_roll_dumbbell	0 max_picth_dumbbell	0 max_yaw_dumbbell
min_roll_dumbbell	min_pitch_dumbbell	min_yaw_dumbbell
amplitude_roll_dumbbell	amplitude_pitch_dumbbell	amplitude_yaw_dumbbell
total_accel_dumbbell	var_accel_dumbbell	avg_roll_dumbbell
stddev_roll_dumbbell	var_roll_dumbbell	avg_pitch_dumbbell
stddev_pitch_dumbbell	var_pitch_dumbbell	avg_yaw_dumbbell
stddev_yaw_dumbbell	var_yaw_dumbbell	gyros_dumbbell_x
gyros_dumbbell_y	gyros_dumbbell_z	accel_dumbbell_x
accel_dumbbell_y	accel_dumbbell_z	magnet_dumbbell_x
magnet_dumbbell_y	magnet_dumbbell_z 0	roll_forearm
pitch_forearm O	yaw_forearm O	kurtosis_roll_forearm
kurtosis_picth_forearm	skewness_roll_forearm	skewness_pitch_forearm
max_roll_forearm	max_picth_forearm	max_yaw_forearm
min_roll_forearm 0	min_pitch_forearm O	min_yaw_forearm O
amplitude_roll_forearm	amplitude_pitch_forearm	amplitude_yaw_forearm
total_accel_forearm	var_accel_forearm	avg_roll_forearm
stddev_roll_forearm 0	var_roll_forearm	avg_pitch_forearm O
stddev_pitch_forearm	var_pitch_forearm	avg_yaw_forearm 0
stddev_yaw_forearm 0	var_yaw_forearm	gyros_forearm_x 0
gyros_forearm_y	gyros_forearm_z	accel_forearm_x
accel_forearm_y	accel_forearm_z	magnet_forearm_x
magnet_forearm_y	magnet_forearm_z	accel_forearm_y.1
accel_forearm_z.1	magnet_forearm_x.1	magnet_forearm_y.1
magnet_forearm_z.1	classe	U
> str(data) 'data.frame': 4024 obs.	of 158 variables:	

```
$ user_name
                       : Factor w/ 5 levels "adelmo", "carlitos", ...: 3 3 3
3 3 3 3 3 3 ...
                       : int 1322489729 1322489729 1322489729
$ raw_timestamp_part_1
1322489729 1322489729 1322489729 1322489729 1322489729 ...
                       : int 34670 62641 70653 82654 90637 170626 190665
$ raw_timestamp_part_2
242723 267551 274689 ...
                       : Factor w/ 7 levels "2/12/2011 13:35",...: 2 2 2 2
$ cvtd_timestamp
2 2 2 2 2 2 ...
                       : Factor w/ 2 levels "no", "yes": 1 1 1 1 1 1 1 1 1
$ new_window
1 ...
                             1 1 1 1 1 1 1 1 1 1 ...
                       : int
$ num_window
                             3.7 3.66 3.58 3.56 3.57 3.45 3.31 2.91 2.31
$ roll_belt
                       : num
2 ...
                             41.6 42.8 43.7 44.4 45.1 45.6 46.2 46.9 47.
$ pitch_belt
                       : num
4 47.7 ...
$ yaw_belt
                             -82.8 -82.5 -82.3 -82.1 -81.9 -81.9 -81.9 -
                       : num
82.2 -82.6 -82.8 ...
$ total_accel_belt
                       : int
                             3 2 1 1 1 1 3 4 2 3 ...
$ kurtosis_roll_belt
                             -1.04 -1.04 -1.04 -1.04 -1.04 ...
                       : num
$ kurtosis_picth_belt
                             -0.391 -0.391 -0.391 -0.391 ...
                       : num
                             0.00541 \ 0.00541 \ 0.00541 \ 0.00541 \ \dots
$ skewness_roll_belt
                       : num
$ skewness_roll_belt.1
                       : num
                             0.0451 0.0451 0.0451 0.0451 0.0451 ...
                             -4.1 -4.1 -4.1 -4.1 -4.1 -4.1 -4.1 -4.1
$ max_roll_belt
                       : num
1 -4.1 ...
                             20 20 20 20 20 20 20 20 20 20 ...
$ max_picth_belt
                       : int
$ max_yaw_belt
                       : num
                             -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 ...
$ 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 ...
                             1.34 1.34 1.34 1.34 ...
$ amplitude_roll_belt
                       : num
$ amplitude_pitch_belt
                             2 2 2 2 2 2 2 2 2 2 ...
                       : int
                             0 0 0 0 0 0 0 0 0 0 ...
$ amplitude_yaw_belt
                       : int
$ var_total_accel_belt
                       : num
                             : num
                             122 122 122 122 122 ...
$ avg_roll_belt
$ stddev_roll_belt
                       : num
                             0.6 0.6 0.6 0.6 0.6 0.6 0.6 0.6 0.6 ...
$ var_roll_belt
                       : num
                             5 0.35 ...
$ avg_pitch_belt
                             25.8 25.8 25.8 25.8 25.8 ...
                       : num
                             $ stddev_pitch_belt
                       : num
5 0.35 ...
                             $ var_pitch_belt
                       : num
                             -4.95 -4.95 -4.95 -4.95 -4.95 -4.95 -
$ avg_yaw_belt
                       : num
4.95 -4.95 -4.95 ...
                             $ stddev_yaw_belt
                       : num
                             $ var_yaw_belt
                       : num
7 0.17 ...
                             2.02 1.96 1.88 1.8 1.77 1.75 1.78 1.75 1.65
$ gyros_belt_x
                       : num
1.48 ...
                      $ min_yaw_dumbbell
-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
                             4 4 4 5 4 4 4 4 4 4 ...
                       : int
                             2.42 2.42 2.42 2.42 ...
$ var_accel_dumbbell
                       : num
                       : num
$ avg_roll_dumbbell
                             -5.12 -5.12 -5.12 -5.12 ...
```

```
[list output truncated]
> summary(data)
                 raw_timestamp_part_1 raw_timestamp_part_2
                                                                    cvtd_time
    user_name
stamp
 adelmo : 311
                 Min.
                        :1.322e+09
                                      Min.
                                                 297
                                                           2/12/2011 13:35 :
311
                 1st Ou.:1.323e+09
                                                           28/11/2011 14:15:
 carlitos:1580
                                      1st Ou.:244321
88
eurico : 88
                 Median :1.323e+09
                                      Median :492342
                                                           30/11/2011 17:12:
4
 jeremy
            4
                 Mean
                        :1.323e+09
                                      Mean
                                             :490377
                                                           5/12/2011 11:23 :
337
                                                           5/12/2011 11:25 :1
 pedro
         :2041
                 3rd Qu.:1.323e+09
                                      3rd Qu.:736278
243
                 Max.
                        :1.323e+09
                                      Max.
                                             :996453
                                                           5/12/2011 14:22 :
456
              num_window
                              roll_belt
                                               pitch_belt
 new_window
                                                                 yaw_belt
 no:3936
           Min. : 1.00
                            Min. :-28.90
                                             Min. :-56.20
                                                              Min. :-179.00
yes: 88
            1st Qu.:24.00
                            1st Qu.: 1.38
                                             1st Qu.: 6.22
                                                              1st Qu.: -93.10
                            Median :122.00
                                                              Median : -4.94
            Median :46.00
                                             Median : 25.50
0
                   :46.33
                            Mean
                                   : 73.31
                                             Mean
                                                   : 14.16
                                                                    : -30.97
            Mean
                                                              Mean
5
            3rd Qu.:69.00
                            3rd Qu.:124.00
                                             3rd Qu.: 26.40
                                                              3rd Ou.: -2.69
5
                   :91.00
                                   :159.00
                                                    : 60.30
                                                                     : 179.00
            Max.
                            Max.
                                             Max.
                                                              Max.
0
 total_accel_belt kurtosis_roll_belt kurtosis_picth_belt skewness_roll_belt
 Min.
       : 0.00
                  Min.
                        :-3.333
                                     Min.
                                            :-2.1212
                                                         Min.
                                                                :-3.031527
 1st Qu.: 3.00
                                                         1st Qu.: 0.005406
                  1st Qu.:-1.036
                                     1st Qu.:-0.3913
 Median :19.00
                                                         Median: 0.005406
                  Median :-1.036
                                     Median :-0.3913
 Mean
        :12.77
                  Mean
                         :-1.027
                                     Mean
                                            :-0.3496
                                                         Mean
                                                                : 0.003858
 3rd Qu.:20.00
                  3rd Qu.:-1.036
                                     3rd Qu.:-0.3913
                                                         3rd Qu.: 0.005406
 Max.
       :26.00
                  Max.
                        : 7.515
                                     Max.
                                            :54.0000
                                                         Max. : 2.713152
 skewness_roll_belt.1 max_roll_belt
                                        max_picth_belt
                                                         max_yaw_belt
       :-6.63325
                      Min. :-94.400
                                        Min. : 3.00
                                                        Min. :-3.3000
 1st Qu.: 0.04512
                      1st Qu.: -4.100
                                        1st Qu.:20.00
                                                        1st Qu.:-1.0000
 Median: 0.04512
                      Median : -4.100
                                        Median :20.00
                                                        Median :-1.0000
        : 0.04011
                                                        Mean :-0.9917
 Mean
                      Mean
                             : -4.626
                                        Mean
                                               :19.87
 3rd Qu.: 0.04512
                      3rd Qu.: -4.100
                                        3rd Qu.:20.00
                                                        3rd Qu.:-1.0000
       : 7.34847
                             :179.000
                                               :26.00
                                                               : 7.5000
 Max.
                      Max.
                                        Max.
                                                        Max.
 min_roll_belt
                    min_pitch_belt
                                                      amplitude_roll_belt
                                     min_yaw_belt
 Min.
        :-179.000
                    Min.
                          : 0.00
                                    Min.
                                           :-3.3000
                                                      Min.
                                                             : 0.000
                    1st Qu.:18.00
                                    1st Qu.:-1.0000
 1st Qu.: -7.250
                                                      1st Qu.:
                                                                1.345
                                    Median :-1.0000
 Median:
         -7.250
                    Median :18.00
                                                      Median :
                                                                1.345
 Mean
          -7.838
                    Mean
                           :17.86
                                    Mean
                                           :-0.9917
                                                      Mean :
                                                                1.446
                                                      3rd Ou.: 1.345
 3rd Ou.: -7.250
                    3rd Ou.:18.00
                                    3rd Ou.:-1.0000
                                                       Max. :1440.0
      : 575.00
                         : 239
                  Max.
                                    Max. : 413.0
 magnet_forearm_z.1 classe
 Min. :-876.0
                    A:1365
 1st Ou.: 370.8
                    B: 901
 Median : 560.0
                    c: 112
        : 475.2
                    D: 276
 Mean
```

3rd Qu.: 670.0

:1040.0

Max.

E:1370

```
[ reached getOption("max.print") -- omitted 1 row ]
> pairs(data[8:15])
> # enable multi-core processing
> library(doParallel)
> #cl <- makeCluster(detectCores())</pre>
> set.seed(12345)
> dataTrain<-data[1:800,]</pre>
> dataTest<-data[805:4024,]</pre>
> head(dataTrain)
  user_name raw_timestamp_part_1 raw_timestamp_part_2 cvtd_timestamp new_wi
ndow
                       1322489729
                                                   34670 28/11/2011 14:15
1
     eurico
no
2
     eurico
                       1322489729
                                                   62641 28/11/2011 14:15
no
3
     eurico
                       1322489729
                                                   70653 28/11/2011 14:15
no
     eurico
                       1322489729
                                                   82654 28/11/2011 14:15
4
no
                       1322489729
                                                   90637 28/11/2011 14:15
5
     eurico
no
     eurico
                       1322489729
                                                  170626 28/11/2011 14:15
6
no
  num_window roll_belt pitch_belt yaw_belt total_accel_belt kurtosis_roll_bel
t
                                       -82.8
                                                              3
           1
                   3.70
                               41.6
1
                                                                           -1.0356
6
                               42.8
                                       -82.5
2
           1
                   3.66
                                                              2
                                                                           -1.0356
6
3
                   3.58
                               43.7
                                       -82.3
           1
                                                              1
                                                                           -1.0356
6
4
                   3.56
                               44.4
                                       -82.1
           1
                                                              1
                                                                           -1.0356
6
5
                               45.1
           1
                   3.57
                                       -81.9
                                                              1
                                                                           -1.0356
6
6
                   3.45
                               45.6
                                       -81.9
                                                                           -1.0356
           1
                                                              1
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
                                                                            -4.1
                                                         0.045115
3
              -0.39133
                                  0.005406
                                                         0.045115
                                                                             -4.1
4
                                  0.005406
              -0.39133
                                                         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
                                         -7.25
                                                            18
                             -1
                                                                          -1
4
               20
                             -1
                                         -7.25
                                                            18
    magnet_forearm_y magnet_forearm_z accel_forearm_y.1 accel_forearm_z.1
805
                 -420
                                    239
                                                       -104
                                                                          -199
                                                                          -204
806
                 -441
                                    219
                                                       -123
807
                 -463
                                    209
                                                       -137
                                                                          -210
808
                 -477
                                    206
                                                       -142
                                                                          -216
809
                 -488
                                                       -152
                                    188
                                                                          -216
                                                       -174
810
                 -502
                                    183
                                                                          -211
    magnet_forearm_x.1 magnet_forearm_y.1 magnet_forearm_z.1 classe
```

```
805
                   -335
                                        -420
                                                              239
                                                                        D
806
                   -293
                                        -441
                                                              219
                                                                        D
807
                   -275
                                        -463
                                                              209
                                                                        D
808
                                        -477
                   -247
                                                              206
                                                                        D
809
                   -212
                                        -488
                                                              188
                                                                        D
                   -201
                                        -502
810
                                                              183
                                                                        D
> indexNA <- as.vector(sapply(dataTrain[,1:152],function(x) {length(which(is.</pre>
na(x)))!=0}))
> dataTrain <- dataTrain[,!indexNA]</pre>
> dataTrain<-na.exclude(dataTrain)</pre>
> library(C50)
> head(dataTrain)
  user_name raw_timestamp_part_1 raw_timestamp_part_2 cvtd_timestamp new_wi
ndow
                        1322489729
                                                    34670 28/11/2011 14:15
1
     eurico
no
2
     eurico
                        1322489729
                                                    62641 28/11/2011 14:15
no
                        1322489729
                                                    70653 28/11/2011 14:15
     eurico
3
no
                        1322489729
                                                    82654 28/11/2011 14:15
4
     eurico
no
                                                    90637 28/11/2011 14:15
5
     eurico
                        1322489729
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
                   3.70
                               41.6
                                        -82.8
                                                               3
1
            1
                                                                            -1.0356
6
                               42.8
                                        -82.5
                                                               2
2
           1
                   3.66
                                                                            -1.0356
6
                   3.58
                                        -82.3
3
           1
                               43.7
                                                               1
                                                                            -1.0356
6
                   3.56
                               44.4
                                        -82.1
                                                               1
4
            1
                                                                            -1.0356
6
5
                   3.57
                               45.1
                                        -81.9
                                                               1
                                                                            -1.0356
           1
6
6
                               45.6
            1
                   3.45
                                        -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
                                   0.005406
              -0.39133
                                                         0.045115
                                                                             -4.1
6
              -0.39133
                                   0.005406
                                                         0.045115
                                                                             -4.1
    magnet_forearm_y magnet_forearm_z accel_forearm_y.1 accel_forearm_z.1
805
                 -420
                                     239
                                                       -104
                                                                           -199
                 -441
                                     219
                                                       -123
806
                                                                           -204
807
                 -463
                                     209
                                                       -137
                                                                           -210
808
                 -477
                                     206
                                                       -142
                                                                           -216
809
                 -488
                                                       -152
                                     188
                                                                           -216
810
                 -502
                                     183
                                                       -174
                                                                           -211
    magnet_forearm_x.1 magnet_forearm_y.1 magnet_forearm_z.1 classe
```

```
805
                  -335
                                     -420
                                                          239
                                                                   D
                  -293
                                     -441
806
                                                          219
                                                                   D
807
                  -275
                                     -463
                                                          209
                                                                   D
                  -247
808
                                     -477
                                                          206
                                                                   D
809
                  -212
                                     -488
                                                          188
                                                                   D
810
                  -201
                                     -502
                                                          183
                                                                   D
> #-----
> library(tree)
> fit <-tree(classe~.,data=dataTrain[,-1])</pre>
> summary(fit)
Classification tree:
tree(formula = classe ~ ., data = dataTrain[, -1])
Variables actually used in tree construction:
[1] "raw_timestamp_part_1"
Number of terminal nodes: 3
Residual mean deviance: 0 = 0 / 797
Misclassification error rate: 0 = 0 / 800
> #fit
> plot(fit)
```

- > text(fit)
- > pred <-predict(fit,dataTest[,-1],type='class')</pre>
- > confusionMatrix(pred,dataTest\$classe)

Confusion Matrix and Statistics

Reference Prediction C D Ε A B 0 0 0 0 0 В 0 0 0 0 0 0 0 0 0 C 0 D 1028 901 112 212 967 Ε 0 0 0 0 0

Overall Statistics

Accuracy: 0.0658 95% CI: (0.0575, 0.075)

No Information Rate: 0.3193

P-Value [Acc > NIR] : 1

Kappa: 0 Mcnemar's Test P-Value : NA

Statistics by Class:

	class: A	Class: B	class: c	Class: D	Class: E
Sensitivity	0.0000	0.0000	0.00000	1.00000	0.0000
Specificity	1.0000	1.0000	1.00000	0.00000	1.0000
Pos Pred Value	Nan	NaN	Nan	0.06584	NaN
Neg Pred Value	0.6807	0.7202	0.96522	NaN	0.6997
Prevalence	0.3193	0.2798	0.03478	0.06584	0.3003
Detection Rate	0.0000	0.0000	0.00000	0.06584	0.0000
Detection Prevalence	0.0000	0.0000	0.00000	1.00000	0.0000

```
Balanced Accuracy
                       0.5000 0.5000 0.50000 0.50000
                                                            0.5000
>
> #----
> library(rpart)
> library(rpart.plot)
> fit1 <- rpart(classe~.,data=dataTrain[,-1])</pre>
n = 800
node), split, n, loss, yval, (yprob)
      * denotes terminal node
1) root 800 397 E (0.42 0 0 0.075 0.5)
  2) raw_timestamp_part_1>=1.322959e+09 397 60 A (0.85 0 0 0.15 0)
                                               0 A (1 0 0 0 0) *
    4) raw_timestamp_part_1< 1.323084e+09 337
    5) raw_timestamp_part_1>=1.323084e+09 60
                                              0 D (0 0 0 1 0) *
  3) raw_timestamp_part_1< 1.322959e+09 403
                                               0 E (0 0 0 0 1) *
> summary(fit1)
call:
rpart(formula = classe ~ ., data = dataTrain[, -1])
  n = 800
         CP nsplit rel error
                                xerror
1 0.8488665
                 0 1.0000000 1.0000000 0.03562151
2 0.1511335
                 1 0.1511335 0.1511335 0.01876532
3 0.0100000
                 2 0.0000000 0.0000000 0.00000000
Variable importance
          num_window raw_timestamp_part_1
                                               accel forearm z
                                                                   accel forea
rm z.1
                  17
                                       17
                                                             13
13
       magnet_belt_x
                        magnet_dumbbell_z
                                                      pitch_arm
                                                                          pitc
h belt
                  13
                                       13
                                                              4
4
            roll_arm
                                 yaw_belt
Node number 1: 800 observations,
                                    complexity param=0.8488665
  predicted class=E expected loss=0.49625 P(node) =1
                    337
    class counts:
                            0
                                       60
   probabilities: 0.421 0.000 0.000 0.075 0.504
  left son=2 (397 obs) right son=3 (403 obs)
  Primary splits:
      raw_timestamp_part_1 < 1322959000 to the right, improve=348.6635, (0 mi
ssing)
                           splits as RRRLL--, improve=348.6635, (0 missing)
      cvtd_timestamp
                                        to the right, improve=348.6635, (0 mi
      num window
                           < 10.5
ssing)
                           < 29.5
                                        to the left, improve=348.6635, (0 mi
      magnet_belt_x
ssing)
      accel_forearm_z
                           < -168
                                        to the left, improve=348.6635, (0 mi
ssing)
  Surrogate splits:
      num_window
                        < 10.5
                                     to the right, agree=1.000, adj=1.000, (0
split)
```

```
magnet_belt_x
                        < 29.5
                                     to the left, agree=1.000, adj=1.000, (0
split)
                                     to the left, agree=1.000, adj=1.000, (0
      accel_forearm_z
                        < -168
split)
                                     to the left, agree=1.000, adj=1.000, (0
      accel_forearm_z.1 < -168
split)
                                     to the left, agree=0.996, adj=0.992, (0
      magnet_dumbbell_z < 10.5
split)
Node number 2: 397 observations,
                                   complexity param=0.1511335
  predicted class=A expected loss=0.1511335 P(node) =0.49625
    class counts:
                    337
                            0
                                  0
                                       60
   probabilities: 0.849 0.000 0.000 0.151 0.000
  left son=4 (337 obs) right son=5 (60 obs)
  Primary splits:
      raw_timestamp_part_1 < 1323084000 to the left, improve=101.864, (0 mis
sing)
                           splits as ---LR--, improve=101.864, (0 missing)
      cvtd_timestamp
                                        to the left, improve=101.864, (0 mis
      num_window
                           < 18.5
sing)
                           < 6.925
                                        to the right, improve=101.864, (0 mis
      pitch_belt
sing)
      yaw_belt
                           < -93.6
                                        to the left, improve=101.864, (0 mis
sing)
  Surrogate splits:
                              to the left, agree=1, adj=1, (0 split)
      num\_window < 18.5
      pitch_belt < 6.925
                              to the right, agree=1, adj=1, (0 split)
                < -93.6
                              to the left, agree=1, adj=1, (0 split)
      yaw_belt
                              to the left, agree=1, adj=1, (0 split)
      roll_arm
                 < -37.7
      pitch arm < 5.175
                              to the right, agree=1, adj=1, (0 split)
Node number 3: 403 observations
  predicted class=E expected loss=0 P(node) =0.50375
    class counts:
                      0
                            0
                                  0
   probabilities: 0.000 0.000 0.000 0.000 1.000
Node number 4: 337 observations
  predicted class=A expected loss=0 P(node) =0.42125
    class counts:
                    337
                            0
   probabilities: 1.000 0.000 0.000 0.000 0.000
Node number 5: 60 observations
  predicted class=D expected loss=0 P(node) =0.075
    class counts:
                     0
                            0
                                  0
                                       60
   probabilities: 0.000 0.000 0.000 1.000 0.000
> # make predictions
> pred <- predict(fit1,dataTest[,-1],type='class')</pre>
> confusionMatrix(pred.dataTest$classe)
Confusion Matrix and Statistics
          Reference
Prediction
              Α
                        C
                             D
                                  Ε
                        0
         Α
              0
                   0
                             0
                                  0
                   0
                        0
                             0
                                  0
         В
              0
         C
              0
                   0
                        0
                             0
                                  0
         D 1028
                901
                     112
                           212
                                967
```

Overall Statistics

Accuracy: 0.0658

95% CI: (0.0575, 0.075)

No Information Rate : 0.3193

P-Value [Acc > NIR] : 1

Kappa: 0 Mcnemar's Test P-Value: NA

Statistics by Class:

```
Class: A Class: B Class: C Class: D Class: E
Sensitivity
                       0.0000
                                 0.0000
                                        0.00000 1.00000
                                                             0.0000
Specificity
                       1.0000
                                 1.0000
                                         1.00000 0.00000
                                                             1.0000
Pos Pred Value
                           Nan
                                    Nan
                                             NaN
                                                  0.06584
                                                                Nan
                                 0.7202
Neg Pred Value
                       0.6807
                                         0.96522
                                                             0.6997
                                                      NaN
                                                  0.06584
Prevalence
                       0.3193
                                 0.2798
                                         0.03478
                                                             0.3003
Detection Rate
                       0.0000
                                 0.0000
                                         0.00000
                                                  0.06584
                                                             0.0000
                                                             0.0000
Detection Prevalence
                       0.0000
                                 0.0000
                                         0.00000
                                                  1.00000
Balanced Accuracy
                       0.5000
                                 0.5000 0.50000 0.50000
                                                             0.5000
> rpart.plot::rpart.plot(fit1)
> # load libraries
> library(caret)
> library(rpart)
> # define training control
> train_control<- trainControl(method="cv", number=10)</pre>
> # train the model
> model<- train(classe~., data=dataTrain, trControl=train_control, method="rp</pre>
art")
> model
Conditional Inference Tree
4000 samples
 157 predictor
   5 classes: 'A', 'B', 'C', 'D', 'E'
No pre-processing
```

maxdepth	mincriterion	Accuracy	Карра
1	0.01	0.5995049	0.3914677
1	0.50	0.5995049	0.3914677
1	0.99	0.5995049	0.3914677
2	0.01	0.7666999	0.6506937
2	0.50	0.7666999	0.6506937
2	0.99	0.7666999	0.6506937
3	0.01	0.9307515	0.8998373
3	0.50	0.9307515	0.8998373
3	0.99	0.9307515	0.8998373

Summary of sample sizes: 3602, 3600, 3600, 3599, 3601, 3599, ...

Resampling: Cross-Validated (10 fold)

Resampling results across tuning parameters:

```
Accuracy was used to select the optimal model using the largest value.
The final values used for the model were maxdepth = 3 and mincriterion = 0.01
> # make predictions
> predictions<- predict(model,dataTest)</pre>
> # append predictions
> pred<- cbind(dataTest,predictions)</pre>
> # summarize results
> confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)</pre>
> confusionMatrix
Confusion Matrix and Statistics
          Reference
Prediction
                        C
              Α
                             D
                                   Ε
         A 1028
                   0
                        0
                              0
                                   0
                 901
                        0
                              0
                                   0
         В
              0
         C
              0
                   0
                      112
                             0
                                   0
                   0
                             0
                                   0
         D
              0
                       0
                   0
                        0 212 967
         Ε
              0
Overall Statistics
               Accuracy : 0.9342
                 95% CI: (0.925, 0.9425)
    No Information Rate: 0.3193
    P-Value [Acc > NIR] : < 2.2e-16
                  Kappa : 0.9071
 Mcnemar's Test P-Value : NA
Statistics by Class:
                     Class: A Class: B Class: C Class: D Class: E
Sensitivity
                       1.0000
                                 1.0000 1.00000 0.00000
                                                            1.0000
Specificity
                       1.0000
                                 1.0000
                                        1.00000 1.00000
                                                            0.9059
Pos Pred Value
                       1.0000
                                 1.0000
                                        1.00000
                                                            0.8202
                                                      NaN
Neg Pred Value
                       1.0000
                                 1.0000
                                        1.00000 0.93416
                                                            1.0000
                                 0.2798
                                                            0.3003
Prevalence
                       0.3193
                                         0.03478 0.06584
Detection Rate
                       0.3193
                                 0.2798
                                         0.03478
                                                  0.00000
                                                            0.3003
Detection Prevalence
                       0.3193
                                 0.2798
                                        0.03478 0.00000
                                                            0.3661
                                 1.0000 1.00000 0.50000
                       1.0000
                                                            0.9530
Balanced Accuracy
> # define training control
> train_control<- trainControl(method="cv", number=10)</pre>
> # train the model
> model<- train(classe~., data=churnTrain, trControl=train_control, method="C</pre>
5.0")
> model
Conditional Inference Tree
4000 samples
 157 predictor
```

```
5 classes: 'A', 'B', 'C', 'D', 'E'
No pre-processing
Resampling: Cross-Validated (10 fold)
Summary of sample sizes: 3602, 3600, 3600, 3599, 3601, 3599, ...
Resampling results across tuning parameters:
  maxdepth mincriterion Accuracy
                                      Kappa
            0.01
                           0.5995049
                                      0.3914677
  1
  1
            0.50
                           0.5995049
                                      0.3914677
  1
            0.99
                           0.5995049
                                      0.3914677
  2
            0.01
                           0.7666999
                                      0.6506937
            0.50
  2
                           0.7666999
                                      0.6506937
  2
            0.99
                           0.7666999
                                      0.6506937
  3
            0.01
                           0.9307515
                                      0.8998373
  3
            0.50
                           0.9307515
                                      0.8998373
  3
            0.99
                           0.9307515
                                      0.8998373
Accuracy was used to select the optimal model using the largest value.
The final values used for the model were maxdepth = 3 and mincriterion = 0.01
> # make predictions
> predictions<- predict(model,dataTest)</pre>
> # append predictions
> pred<- cbind(dataTest,predictions)</pre>
> # summarize results
> confusionMatrix<- confusionMatrix(pred$predictions.pred$classe)</pre>
> confusionMatrix
Confusion Matrix and Statistics
          Reference
Prediction
              Α
                         C
                              D
                                   Ε
         A 1028
                                   0
                   0
                         0
                              0
                 901
                        0
                              0
                                   0
         В
              0
         C
              0
                   0
                      112
                              0
                                   0
         D
              0
                   0
                         0
                              0
                                   0
         F
              0
                   0
                         0
                           212
                                 967
Overall Statistics
               Accuracy : 0.9342
                 95% CI: (0.925, 0.9425)
    No Information Rate: 0.3193
    P-Value [Acc > NIR] : < 2.2e-16
                  Kappa : 0.9071
 Mcnemar's Test P-Value: NA
Statistics by Class:
                      Class: A Class: B Class: C Class: D Class: E
                                 1.0000 1.00000 0.00000
Sensitivity
                        1.0000
                                                             1.0000
```

1.0000 1.00000 1.00000

1.0000 1.00000 0.93416

1.00000

1.0000

0.9059

0.8202

1.0000

NaN

1.0000

1.0000

1.0000

Specificity
Pos Pred Value

Neg Pred Value

```
0.3003
Prevalence
                       0.3193
                                0.2798 0.03478 0.06584
Detection Rate
                       0.3193
                                 0.2798
                                         0.03478 0.00000
                                                            0.3003
                       0.3193
                                         0.03478
Detection Prevalence
                                 0.2798
                                                  0.00000
                                                            0.3661
Balanced Accuracy
                       1.0000
                                1.0000 1.00000 0.50000
                                                            0.9530
> #-----# define training control
> train_control<- trainControl(method="cv", number=10)</pre>
> # train the model
> model<- train(classe~., data=churnTrain, trControl=train_control, method="b
stTree")
> model
Conditional Inference Tree
4000 samples
 157 predictor
   5 classes: 'A', 'B', 'C', 'D', 'E'
No pre-processing
Resampling: Cross-Validated (10 fold)
summary of sample sizes: 3602, 3600, 3600, 3599, 3601, 3599, ...
Resampling results across tuning parameters:
  maxdepth mincriterion Accuracy
  1
            0.01
                          0.5995049
                                      0.3914677
  1
            0.50
                          0.5995049
                                     0.3914677
                                     0.3914677
  1
            0.99
                          0.5995049
  2
            0.01
                          0.7666999
                                      0.6506937
  2
            0.50
                          0.7666999
                                      0.6506937
  2
            0.99
                          0.7666999
                                      0.6506937
                          0.9307515
  3
            0.01
                                      0.8998373
  3
                          0.9307515
            0.50
                                      0.8998373
  3
            0.99
                          0.9307515
                                      0.8998373
Accuracy was used to select the optimal model using the largest value.
The final values used for the model were maxdepth = 3 and mincriterion = 0.01
> # make predictions
> predictions<- predict(model,dataTest)</pre>
> # append predictions
> pred<- cbind(dataTest,predictions)</pre>
> # summarize results
> confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)</pre>
> confusionMatrix
Confusion Matrix and Statistics
          Reference
Prediction
              Α
                   В
                        C
                             D
                                   Ε
         A 1028
                             0
                   0
                        0
                                   0
                 901
         В
              0
                        0
                             0
                                   0
                      112
                             0
                                   0
         C
              0
                   0
                   0
                             0
                                   0
         D
              0
                        0
                           212
         Ε
              0
                   0
                        0
                                967
```

Overall Statistics

```
Accuracy : 0.9342
                 95% CI: (0.925, 0.9425)
    No Information Rate: 0.3193
    P-Value [Acc > NIR] : < 2.2e-16
                  Kappa : 0.9071
 Mcnemar's Test P-Value: NA
Statistics by Class:
                     Class: A Class: B Class: C Class: D Class: E
Sensitivity
                       1.0000
                                1.0000 1.00000 0.00000
                                                           1.0000
Specificity
                       1.0000
                                1.0000
                                       1.00000 1.00000
                                                           0.9059
Pos Pred Value
                       1.0000
                                1.0000
                                       1.00000
                                                           0.8202
                                                     NaN
Neg Pred Value
                                1.0000
                                       1.00000 0.93416
                                                           1.0000
                       1.0000
                                0.2798
Prevalence
                       0.3193
                                        0.03478
                                                 0.06584
                                                           0.3003
Detection Rate
                       0.3193
                                0.2798
                                        0.03478
                                                 0.00000
                                                           0.3003
Detection Prevalence
                       0.3193
                                0.2798
                                        0.03478 0.00000
                                                           0.3661
Balanced Accuracy
                       1.0000
                                1.0000 1.00000 0.50000
                                                           0.9530
>
> #-----
> # define training control
> train_control<- trainControl(method="cv", number=10)</pre>
> # train the model
> model<- train(classe~., data=dataTrain, trControl=train_control, method="C5</pre>
Error: One or more factor levels in the outcome has no data: 'B', 'C'
> model
Conditional Inference Tree
4000 samples
 157 predictor
   5 classes: 'A', 'B', 'C', 'D', 'E'
No pre-processing
Resampling: Cross-Validated (10 fold)
Summary of sample sizes: 3602, 3600, 3600, 3599, 3601, 3599, ...
Resampling results across tuning parameters:
  maxdepth mincriterion Accuracy
                                     Карра
  1
            0.01
                          0.5995049
                                     0.3914677
  1
            0.50
                          0.5995049
                                     0.3914677
  1
            0.99
                          0.5995049
                                     0.3914677
  2
            0.01
                          0.7666999
                                     0.6506937
  2
            0.50
                          0.7666999
                                     0.6506937
                          0.7666999
  2
            0.99
                                     0.6506937
  3
            0.01
                          0.9307515
                                     0.8998373
  3
            0.50
                          0.9307515
                                     0.8998373
            0.99
                          0.9307515
                                     0.8998373
Accuracy was used to select the optimal model using the largest value.
```

The final values used for the model were maxdepth = 3 and mincriterion = 0.01

```
> # make predictions
> predictions<- predict(model,dataTest)</pre>
> # append predictions
> pred<- cbind(dataTest,predictions)</pre>
> # summarize results
> confusionMatrix<- confusionMatrix(pred$predictions.pred$classe)</pre>
> confusionMatrix
Confusion Matrix and Statistics
          Reference
Prediction
                 В
              Α
                        C
                             D
                                   Ε
         A 1028
                   0
                        0
                             0
                                   0
         В
              0
                 901
                        0
                             0
                                   0
         C
              0
                   0
                      112
                             0
                                   0
                   0
                        0
                             0
                                   0
         D
              0
                   0
                        0 212
                                967
         Ε
              0
Overall Statistics
               Accuracy : 0.9342
                 95% CI: (0.925, 0.9425)
    No Information Rate: 0.3193
    P-Value [Acc > NIR] : < 2.2e-16
                  Kappa : 0.9071
 Mcnemar's Test P-Value : NA
Statistics by Class:
                     Class: A Class: B Class: C Class: D Class: E
Sensitivity
                       1.0000
                                1.0000 1.00000 0.00000
                                                            1.0000
                                         1.00000 1.00000
                                 1.0000
Specificity
                       1.0000
                                                            0.9059
                                1.0000
                                        1.00000
Pos Pred Value
                       1.0000
                                                      NaN
                                                            0.8202
                                1.0000
                                        1.00000 0.93416
                                                            1.0000
Neg Pred Value
                       1.0000
                                                            0.3003
Prevalence
                       0.3193
                                0.2798 0.03478 0.06584
Detection Rate
                       0.3193
                                0.2798
                                         0.03478 0.00000
                                                            0.3003
Detection Prevalence
                       0.3193
                                0.2798
                                         0.03478 0.00000
                                                            0.3661
Balanced Accuracy
                       1.0000
                                1.0000 1.00000 0.50000
                                                            0.9530
> # define training control
> train_control<- trainControl(method="cv", number=10)</pre>
> # train the model
> model<- train(classe~., data=dataTrain, trControl=train_control, method="C5</pre>
.ORules")
> model
Conditional Inference Tree
4000 samples
 157 predictor
   5 classes: 'A', 'B', 'C', 'D', 'E'
No pre-processing
```

Resampling: Cross-Validated (10 fold) Summary of sample sizes: 3602, 3600, 3600, 3599, 3601, 3599, ... Resampling results across tuning parameters:

maxdepth	mincriterion	Accuracy	Карра
1	0.01	0.5995049	0.3914677
1	0.50	0.5995049	0.3914677
1	0.99	0.5995049	0.3914677
2	0.01	0.7666999	0.6506937
2	0.50	0.7666999	0.6506937
2	0.99	0.7666999	0.6506937
3	0.01	0.9307515	0.8998373
3	0.50	0.9307515	0.8998373
3	0.99	0.9307515	0.8998373

Accuracy was used to select the optimal model using the largest value. The final values used for the model were maxdepth = 3 and mincriterion = 0.01

- > # make predictions
- > predictions<- predict(model,dataTest)</pre>
- >
- > # append predictions
- > pred<- cbind(dataTest,predictions)</pre>
- >
- > # summarize results
- > confusionMatrix<- confusionMatrix(pred\$predictions,pred\$classe)</pre>
- > confusionMatrix

Confusion Matrix and Statistics

Reference

Prediction	Α	В	C	D	Ε
Α	1028	0	0	0	0
В	0	901	0	0	0
C	0	0	112	0	0
D	0	0	0	0	0
E	0	0	0	212	967

Overall Statistics

Accuracy: 0.9342

95% CI: (0.925, 0.9425)

No Information Rate : 0.3193 P-Value [Acc > NIR] : < 2.2e-16

Kappa : 0.9071

Mcnemar's Test P-Value : NA

Statistics by Class:

	Class: A	Class: B	Class: C	Class: D	Class: E
Sensitivity	1.0000	1.0000	1.00000	0.00000	1.0000
Specificity	1.0000	1.0000	1.00000	1.00000	0.9059
Pos Pred Value	1.0000	1.0000	1.00000	NaN	0.8202
Neg Pred Value	1.0000	1.0000	1.00000	0.93416	1.0000
Prevalence	0.3193	0.2798	0.03478	0.06584	0.3003
Detection Rate	0.3193	0.2798	0.03478	0.00000	0.3003
Detection Prevalence	0.3193	0.2798	0.03478	0.00000	0.3661

```
1.0000 1.0000 1.00000 0.50000
Balanced Accuracy
                                                             0.9530
> #-----
> # define training control
> train_control<- trainControl(method="cv", number=10)</pre>
> # train the model
> model<- train(classe~., data=dataTrain, trControl=train_control, method="C5</pre>
.0Tree")
> model
Conditional Inference Tree
4000 samples
 157 predictor
   5 classes: 'A', 'B', 'C', 'D', 'E'
No pre-processing
Resampling: Cross-Validated (10 fold)
Summary of sample sizes: 3602, 3600, 3600, 3599, 3601, 3599, ...
Resampling results across tuning parameters:
  maxdepth mincriterion Accuracy
                                      Карра
            0.01
                          0.5995049
                                      0.3914677
  1
  1
            0.50
                           0.5995049
                                      0.3914677
  1
            0.99
                           0.5995049
                                      0.3914677
  2
                           0.7666999
            0.01
                                      0.6506937
  2
            0.50
                           0.7666999
                                      0.6506937
  2
            0.99
                           0.7666999
                                      0.6506937
  3
            0.01
                          0.9307515
                                      0.8998373
  3
            0.50
                          0.9307515
                                      0.8998373
  3
            0.99
                          0.9307515 0.8998373
Accuracy was used to select the optimal model using the largest value.
The final values used for the model were maxdepth = 3 and mincriterion = 0.01
> # make predictions
> predictions<- predict(model,dataTest)</pre>
> # append predictions
> pred<- cbind(dataTest,predictions)</pre>
> # summarize results
> confusionMatrix<- confusionMatrix(pred$predictions,pred$classe)</pre>
> confusionMatrix
Confusion Matrix and Statistics
          Reference
Prediction
                        C
                              D
                                   Ε
              Α
                   R
         A 1028
                        0
                              0
                   0
                                   0
                 901
                                   0
         В
              0
                        0
                              0
         C
                      112
                              0
                                   0
              0
                   0
                   0
                             0
                                   0
         D
              0
                        0
         Ε
              0
                   0
                        0 212
                                 967
```

Overall Statistics

Accuracy : 0.9342 95% CI: (0.925, 0.9425) No Information Rate: 0.3193 P-Value [Acc > NIR] : < 2.2e-16Kappa : 0.9071 Mcnemar's Test P-Value : NA Statistics by Class: Class: A Class: B Class: C Class: D Class: E 1.0000 1.00000 0.00000 Sensitivity 1.0000 1.0000 1.0000 Specificity 1.0000 1.00000 1.00000 0.9059 1.0000 Pos Pred Value 1.0000 1.00000 NaN 0.8202 Neg Pred Value 1.0000 1.0000 1.00000 0.93416 1.0000 Prevalence 0.03478 0.06584 0.3003 0.3193 0.2798 Detection Rate 0.3003 0.3193 0.2798 0.03478 0.00000 Detection Prevalence 0.3193 0.2798 0.03478 0.00000 0.3661 Balanced Accuracy 1.0000 1.0000 1.00000 0.50000 0.9530 > # define training control > train_control<- trainControl(method="cv", number=10)</pre> > # train the model > model<- train(classe~., data=dataTrain, trControl=train_control, method="ct</pre> ree") > model Conditional Inference Tree 4000 samples 157 predictor 5 classes: 'A', 'B', 'C', 'D', 'E' No pre-processing Resampling: Cross-Validated (10 fold) Summary of sample sizes: 3602, 3600, 3600, 3599, 3601, 3599, ... Resampling results across tuning parameters: maxdepth mincriterion Accuracy Карра 1 0.010.5995049 0.3914677 1 0.50 0.5995049 0.3914677 0.99 1 0.5995049 0.3914677 2 0.7666999 0.010.6506937 2 0.50 0.7666999 0.6506937 2 0.99 0.7666999 0.6506937 3 0.9307515 0.01 0.8998373 3 0.50 0.9307515 0.8998373 0.99 0.9307515 0.8998373 Accuracy was used to select the optimal model using the largest value. The final values used for the model were maxdepth = 3 and mincriterion = 0.01

> # make predictions

```
> predictions<- predict(model,dataTest)</pre>
> # append predictions
> pred<- cbind(dataTest,predictions)</pre>
> # summarize results
> confusionMatrix<- confusionMatrix(pred$predictions.pred$classe)</pre>
> confusionMatrix
Confusion Matrix and Statistics
          Reference
Prediction
              Δ
                  R
                        C
                             D
                                  Ε
         A 1028
                   0
                        0
                             0
                                  0
              0 901
                                  0
         В
                        0
                             0
         C
              0
                   0 112
                             0
                                  0
         D
              0
                   0
                        0
                             0
                                  0
         F
              0
                   0
                        0 212
                                967
Overall Statistics
               Accuracy : 0.9342
                 95% CI: (0.925, 0.9425)
    No Information Rate: 0.3193
    P-Value [Acc > NIR] : < 2.2e-16
                  Kappa : 0.9071
 Mcnemar's Test P-Value : NA
Statistics by Class:
                     Class: A Class: B Class: C Class: D Class: E
                                1.0000 1.00000 0.00000
Sensitivity
                       1.0000
                                                            1.0000
                                1.0000
                                        1.00000 1.00000
Specificity
                       1.0000
                                                            0.9059
Pos Pred Value
                       1.0000
                                1.0000
                                        1.00000
                                                      NaN
                                                            0.8202
                                1.0000
                                        1.00000 0.93416
Neg Pred Value
                       1.0000
                                                            1.0000
                                                            0.3003
Prevalence
                       0.3193
                                0.2798
                                        0.03478 0.06584
Detection Rate
                       0.3193
                                0.2798 0.03478 0.00000
                                                            0.3003
Detection Prevalence
                       0.3193
                                0.2798 0.03478 0.00000
                                                            0.3661
Balanced Accuracy
                       1.0000
                                1.0000 1.00000 0.50000
                                                            0.9530
> # define training control
> train_control<- trainControl(method="cv", number=10)</pre>
> # train the model
> model<- train(classe~., data=dataTrain, trControl=train_control, method="ct</pre>
ree2")
> model
Conditional Inference Tree
4000 samples
 157 predictor
   5 classes: 'A', 'B', 'C', 'D', 'E'
No pre-processing
Resampling: Cross-Validated (10 fold)
```

Summary of sample sizes: 3602, 3600, 3600, 3599, 3601, 3599, ... Resampling results across tuning parameters:

```
maxdepth mincriterion Accuracy
                                 Карра
         0.01
                       0.5995049 0.3914677
1
         0.50
                       0.5995049 0.3914677
         0.99
1
                       0.5995049 0.3914677
         0.01
                       0.7666999 0.6506937
2
         0.50
                       0.7666999 0.6506937
2
         0.99
                       0.7666999 0.6506937
3
         0.01
                       0.9307515 0.8998373
3
         0.50
                       0.9307515 0.8998373
         0.99
                       0.9307515 0.8998373
```

Accuracy was used to select the optimal model using the largest value. The final values used for the model were maxdepth = 3 and mincriterion = 0.01

- > # make predictions
- > predictions<- predict(model,dataTest)</pre>
- > # append predictions
- > pred<- cbind(dataTest,predictions)</pre>
- >
- > # summarize results
- > confusionMatrix<- confusionMatrix(pred\$predictions,pred\$classe)</pre>
- > confusionMatrix

Confusion Matrix and Statistics

Reference

Prediction	Α	В	C	D	Ε
Α	1028	0	0	0	0
В	0	901	0	0	0
C	0	0	112	0	0
D	0	0	0	0	0
E	0	0	0	212	967

Overall Statistics

Accuracy : 0.9342

95% CI: (0.925, 0.9425)

No Information Rate : 0.3193 P-Value [Acc > NIR] : < 2.2e-16

карра: 0.9071

Mcnemar's Test P-Value : NA

Statistics by Class:

	Class: A	Class: B	Class: C	Class: D	Class: E
Sensitivity	1.0000	1.0000	1.00000	0.00000	1.0000
Specificity	1.0000	1.0000	1.00000	1.00000	0.9059
Pos Pred Value	1.0000	1.0000	1.00000	NaN	0.8202
Neg Pred Value	1.0000	1.0000	1.00000	0.93416	1.0000
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Detection Rate	0.3193	0.2798	0.03478	0.00000	0.3003
Detection Prevalence	0.3193	0.2798	0.03478	0.00000	0.3661
Balanced Accuracy	1.0000	1.0000	1.00000	0.50000	0.9530

